THE NOVEMBER SCIENTIFIC MONTHLY

Edited by

J. McKEEN CATTELL, F. R. MOULTON AND WARE CATTELL

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NEW BOOKS OF SCIENTIFIC INTEREST

The Milky Way. B. J. and P. F. Bok. Illustrated. v + 204 pp. $2.50. September, 1941. Blakiston.

Presented in a semi-popular form, this volume, one of the Harvard Books on Astronomy, describes the Milky Way. In addition to the composition and dimension of our own galaxy and its parts, problems related to its past and future are discussed.

Modern Flight. C. P. Clevenger. Illustrated. 304 pp. $2.95. 1941. Noble and Noble.

The author attempts to explain in easy-to-understand language the science of flying, following each phase from the elementary physics of aviation to acrobatic maneuvers and cross-country flying. To elucidate flying directions in the text, there are step-by-step diagrams of planes in flight.

Torch and Crucible. S. J. French. ix + 285 pp. $3.50. September, 1941. Princeton.

This biography of Antoine Lavoisier, the "father of modern chemistry," tells of his life and work against a background of great men and epochal events. Lavoisier's scientific contributions are explained, but the emphasis is placed upon a synthesis of his mind, personality and career.

Medicine and Human Welfare. H. E. Sigerist. Illustrated. xiii + 148 pp. $2.50. March, 1941. Yale.

The purpose of this book is to discuss the relationships between medicine and human welfare and to clarify the present situation of public health by analyzing it historically and sociologically. The book's three chapters are: "Disease," "Health," "The Physician."

Fundamentals of Plant Science. M. E. O'Hanlon. Illustrated. 467 pp. $4.25. June, 1941. Crofts.

The author intends this volume as a textbook for college botany courses which the majority of the students are taking primarily for its general cultural value rather than as a prerequisite for professional botany. There are bibliographic suggestions for the advanced student and instructor.

Natural History and the American Mind. W. M. and M. S. C. Smallwood. Illustrated. xv + 445 pp. $4.25. September, 1941. Columbia.

This is the story of the early American naturalists and their influence upon the cultural life of the American people. Although the study of living things has been emphasized, some attention has been given to geology and mineralogy.

The Social Life of Primitive Man. S. S. Sieber and F. H. Mueller. xiii + 566 pp. $3.50. 1941. Herder.

This book is divided into three parts: primitive, primary, and secondary cultures. The author considers marriage, family, government, property, economic life and other aspects of the first two groups, and the more intricate culture circles of the third.

The Folk Culture of Yucatan. R. Redfield. Illustrated. xxiii + 416 pp. $3.50. August, 1941. Chicago.

The contrast between urban Spanish civilization and primitive Maya life is discussed in this book, showing the differences in folklore, culture and religious expression. The author includes in his treatment secularization, individualization, and other phases of culture study.

Leaders of Medicine. S. R. Kagan. Illustrated. 176 pp. $3.00. 1941. Medico-Historical.

Biographical sketches of twelve outstanding American and European physicians are presented in this volume. The biographies are of Henle, Virchow, Mitchell, Jacobi, Allbutt, Solis-Cohen, Billings, Cohnheim, Weigert, Osler, Welch and Ehrlich. Emphasis is placed upon their contributions to medicine.

Photographing Animals. W. Suschitzky. Illustrated. 80 pp. $3.50. August, 1941. Studio.

Practical suggestions on the problems of photographing domestic pets, farmyard animals and animals in zoos are presented in this book, which has an introduction by Julian Huxley. Pasted opposite each page of text are actual photographs, forty-two in all, taken by the author.

Lives and Dollars. J. D. Ratcliff. ix + 225 pp. $3.00. September, 1941. Dodd, Mead.

The author presents for the layman the story of recent and current research work in many fields of science with emphasis placed upon the medical sciences. There are chapters on such widely varied subjects as health and disease, agricultural chemistry, insect pests and atomic physics.

An Apache Life-Way. M. E. Opler. Illustrated. xvii + 500 pp. $5.00. October, 1941. Chicago.

The economic, social and religious institutions of the Chiricahua Apache Indians, as they existed a generation ago, are described in this book. Events discussed are introduced in the order in which they are experienced in the course of the normal Apache life-cycle, in order to give a unified picture of their life.

Science Calls to Youth. R. F. Yates. Illustrated. xiii + 205 pp. $2.00. September, 1941. Appleton-Century.

This is a guide for young people to career-planning in the sciences. It discusses recent developments in science, value of a college education versus practical experience, need of specialization, scientific frame of mind, and the influence of science on society.

Your Personality—Introvert or Extravert? V. Case. viii + 277 pp. $2.50. 1941. Macmillan.

This book intends to make clear the psychological types, introvert and extravert, which the author considers to be currently widely misunderstood, and to bring to the general public a practical knowledge of human nature. Chapter summaries and suggested readings follow the text.

THE SCIENTIFIC MONTHLY

NOVEMBER, 1941

LANDS BENEATH THE SEA

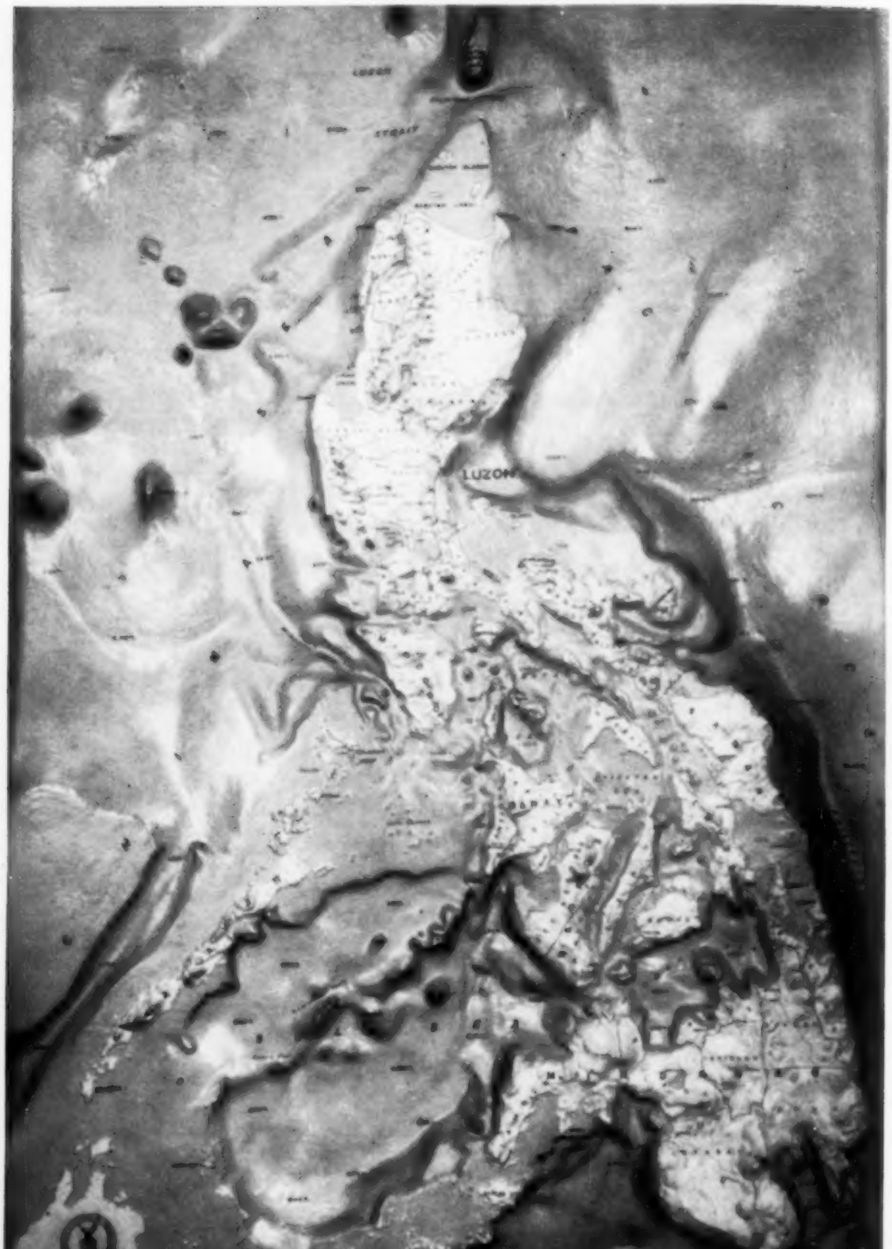
By PAUL A. SMITH

UNITED STATES COAST AND GEODETIC SURVEY

An atmosphere suggestive of the legends of Lemuria, Atlantis and other myths of the lost continents sung by the bards of antiquity has, to some extent, surrounded studies of submarine relief. It may be that this is the natural result of the attraction of the imagination to the unknown. When one reflects how, in past centuries, the unexplored areas of the earth's surface have been peopled by strange and awful monstrosities which we now know existed only in the human fancy, it is not surprising that the human imagination has been so strongly stimulated by speculation on the forms of lands beneath the sea, as well as the forms of life dwelling within the sea. Here, as in other explorations into the unknown, the cold light of fact disperses the shadows of uncertainty; and the ocean deeps, submerged mountains and valleys, plateaus and plains, are gradually becoming known well enough through the accumulation of soundings so that we can begin to study their shapes—their physiographic characteristics—and even draw conclusions with some degree of certainty about the relations between the geologic history of adjacent land and water areas. Topographic features beneath the sea must, of course, be mapped and studied by indirect means because they can not be seen, at least not over extensive areas. The fact that they are for the most part invisible to human eyes, and probably will remain so for some years to come, lends an air of mystery to them.

Our knowledge of the approximate limits of the great ocean deeps, extensive ridges and large submarine features of continental proportions is now fairly good. We know, for example, of the existence and even the approximate limits of the great Atlantic Ridge, the Easter Island Ridge, the Philippine Trough, Aleutian Trough and numerous other major submarine features, even though many of them are covered with at least a thousand fathoms of water. By "fairly good" is meant that it is about as complete (by crude analogy) as was the map of the continents of the world at the beginning of the seventeenth century. The International Hydrographic Bureau has done much to collect such information, and the ships of the United States and foreign navies have, by taking soundings along their routes, contributed extensively to the general knowledge of the bottom relief of oceanic areas.

In a few coastal regions where intensive charting surveys have been made by modern methods, such as those perfected by the United States Coast and Geodetic Survey, even the precise details of form are known; and it is largely upon the results of these well-sounded coastal areas that new concepts of the geologic



Coast and Geodetic Survey, Manila

GENERALIZED SUBMARINE RELIEF MAP OF THE PHILIPPINES.

THE DEEPEST SOUNDING IN THE WORLD, 35,400 FEET, WAS OBTAINED IN THE DEEP EAST OF MINDANAO ISLAND (LOWER RIGHT IN PHOTOGRAPH).

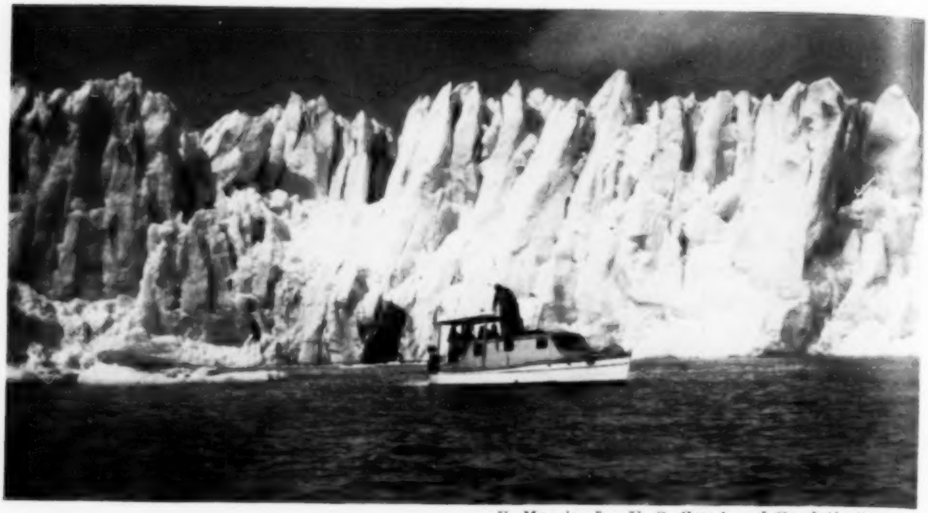
relation between continents and ocean basins are being formed. An explanation of the origin of continents and ocean basins satisfactory to all branches of earth science has yet to be made, but the development of automatic depth recorders and accurate methods of position finding at sea within the past two decades have contributed important additions to our knowledge. It is not desirable here to elaborate upon the methods of survey or the fundamental practical purpose of the surveys, namely, to provide accurate and reliable nautical charts. That is a fascinating story in itself. It is, I believe, important to note that due to modern charting surveys there are few places in the world where we have better knowledge of the relief of submerged continental margins than about the shores of the United States, Alaska and the Philippine Islands. The geologic significance of the results of the surveys is an interesting and not unimportant by-product, and this note is devoted to a brief description of a few of the submarine forms, a more complete knowledge of which may contribute to a better understanding of that part of earth history hidden beneath the sea.

With a few exceptions it is generally assumed by geologists that the present continental masses and ocean basins have not changed much in position throughout the geologic ages since pre-Cambrian time, a matter of at least 600,000,000 years. Crustal warpings and squirmings are supposed to have spread the oceans over extensive areas of the present continents upon a number of occasions, forming the shallow epicontinental seas in which vast layers of sediment were deposited. These assumed conditions, based on many geologic observations and numerous lines of sound reasoning, satisfy most branches of geologic science; but there has always been some difficulty in explaining such things as the existence of many identical land-dwelling flora and fauna as well as littoral forms without some land connection in the past between the continents on which they are found. These continents are now sepa-

Photo by Clarence E. Petersen, U. S. Coast and Geodetic Survey

SURVEYS OF THE SHORE PREPARATORY TO SURVEYS BENEATH THE SEA.

COAST AND GEODETIC SURVEY TOPOGRAPHIC PARTY IN TAKU INLET, ALASKA, 1937.



E. Morris, Jr., U. S. Coast and Geodetic Survey

SOUNDING PARTY IN FRONT OF TAKU GLACIER.

THE OLD HAND LEAD IN USE IN THIS PHOTOGRAPH IS RAPIDLY BEING REPLACED BY AUTOMATIC DEPTH RECORDERS. LAUNCHES ARE USED TO SURVEY THE SHALLOWER COASTAL WATERS.

rated by many miles of deep ocean waters that make an impassable barrier to the forms of life in question.

It has been concluded by geologists that world-wide changes of the sea-level have occurred several times during the last million years or so. These changes in sea-level are supposed to have been caused by the evaporation of sea water which would be necessary to account for the great ice caps of the Pleistocene epoch. Various estimates of this "eustatic lowering" of sea-level have been made in recent years, but some figure of the order of 300 feet is probably tentatively accepted by the majority.

But in the light of the new surveys, the forms of the lands beneath the sea—their physiography—seem to indicate that the ocean waters may have been withdrawn in much greater quantities and within such late geologic time as to account for the migration of certain species over "land bridges" between the continents. In some cases a change of at least 10,000 feet between sea-level and land is indicated by the seavalleys. The weight of evidence against such a great change between land and sea is large. Existing geologic theories based upon the assumption of permanent continents and ocean basins are so firmly established that any idea opposing it encounters seas of opposition almost as vast as those of the real oceans of the earth, which have until recently hidden the important evidence now coming to light. A few of the facts in submarine physiography that support it, however, deserve mention.

It is difficult to describe submerged land forms without large maps or chart sections, but a few of the most striking examples may lend themselves to satisfactory reproduction within the limits of this journal. It must be done by contours, that is, by drawing lines of equal depth based on soundings. This is tedious work, requiring painstaking study of hundreds of thousands of soundings. Relief maps or models may be made from such contoured charts and they are usually preferred by the average reader.

It is interesting to note in passing that the first use of contour lines for repre-

senting relief was made in delineating submarine features and not land forms above the sea. A Dutch engineer and surveyor, Cruquius, made a contour chart of the Merwede River in 1728.

In the intervening years contours have come into general use for showing land relief, but nautical charts have not until quite recently carried more than a few highly generalized "depth curves." There was good reason for this. When beyond sight of land ships could not be located accurately in position, that is, "accurately" as a surveyor defines the term; so that positions of the soundings as charted were frequently several miles away from their actual positions. Also, in order to take soundings in water deeper than about 100 feet it was necessary when using the old hand lead or deep sea lead to stop the ship and lower a weight on a line until it touched bottom, measuring the amount of rope or wire payed out. Soundings in deep water, therefore, required so much time that up until about 1925 very few soundings had been taken in the deeper waters beyond the edges of the continental shelves. And such soundings as were on the charts, except those near shore, were subject to so much error in position that attempts to draw contours inevitably resulted in unsatisfactory generalized sketches.

Coupled with the limitations in accuracy of position and paucity of soundings was the well-established idea that all ocean bottoms were the repositories of the sediments eroded off the lands and carried into the sea by rivers for the past hundreds of millions of years.

Such "basins of deposition" must,

New York Daily Mirror

DORSEY FATHOMETER RECORDING 20 SOUNDINGS PER SECOND.

COMMANDER F. S. BORDEN READS AT A GLANCE THE DEPTH OF WATER BENEATH HIS SURVEY SHIP FROM THE DIALS OF THE MOST PRECISE DEPTH INDICATOR YET CONSTRUCTED.

according to this idea, be characterized by the smooth, gentle slopes one might logically expect to find under such conditions. The more thorough and accurate surveys made in shoaler waters on the continental shelves near shore and within sight of land supported this hypothesis. So it was not until echo sounding was perfected and applied to marine surveying (beginning about 1926) that the true nature of deep submarine relief was realized. About the same time a method utilizing sound and radio, known as radio acoustic ranging, was being developed by the Coast and Geodetic Survey for accurate position finding out of sight of land. The past two decades, therefore, have seen the accumulation of more accurate and thorough coastal surveys than in all preceding history; and these accurate surveys with many continuous profiles obtained through automatic depth recorders have made it possible to produce contour charts of submarine relief.

Probably nowhere in the world can one find a greater variety of land forms in so small an area, both above and below the sea, than in the Philippine Islands region. The relief of the submerged areas around the Archipelago varies from the broad, flat, continental shelves less than 500 feet deep, such as the submerged platforms of Palawan Island and the numerous islands of the Sulu Archipelago, to the greatest known ocean deep, 35,400 feet, just east of Mindanao. This is about 6½ miles deep, and it is interesting to note that Mount Everest, the world's highest peak, if placed in this abyss would still be covered by over a mile of sea water. The Sulu Sea is a mediterranean sea in that this large basin, over 17,000 feet deep in places, and about 250 miles in diameter, is cut off from the exterior seas (the China Sea to the west, Pacific Ocean on the east, and Celebes Sea on the south) by the shallow submerged edges, or rims, of the bowl. The deepest part or th[illegible] this submerged rim is only ab[illegible] feet below sea-level. Hydrogra[illegible]veys by the Coast and Geodeti[illegible]vey have been in progress in the wa[illegible]rs surrounding the Islands since 1901, and these surveys, now well advanced, show many striking submarine features. A number of active volcanoes on the islands above the sea, combined with lively seismic or earthquake activity, make a complex and interesting—one might almost say exciting—geologic combination.

Two large drainage basins are found in the Islands. The Cagayan River on Luzon Island flows north into Babuyan Channel; and seaward from its mouth, heading almost within the river estuary, is a submarine valley cut a thousand feet down into the ocean floor. It is obviously a continuation of the present Cagayan River.

The Mindanao River is a more striking case of this type. Here the present river flows into the Celebes Sea through two prominent distributary channels, and a knoll 600 feet high separates the river mouths at the present coast line. Seaward from the present shore the hydrographic surveys show two deep well-developed seavalleys, each heading precisely from the shore at each river mouth.

On the other side of the world the mighty Congo River of Africa, second largest river in the world, empties into the Atlantic Ocean through a long estuary, and the deepest known submarine canyon (5,000 feet) has been cut over 20 miles back into this estuary. The head of the Congo Seavalley is over 80 miles inside what is called the "edge" of the continental shelf. In still another part of the world the "Sacred River of the Hindus," the Ganges, debouches into the Bay of Bengal through a crocodile infested, jungle delta 200 miles wide, which is known locally as the Sundar-

W. Weidlich, U. S. Coast and Geodetic Survey

U. S. COAST AND GEODETIC SURVEY SHIP, IN RUDYERD BAY, ALASKA.

SOUNDINGS SHOW THAT SUCH RUGGED LAND FORMS AS SEEN HERE ALSO EXIST MANY FATHOMS BENEATH THE SEA. THE VESSEL IS THE OLD "EXPLORER," NOW REPLACED BY A MODERN SURVEY SHIP OF THE SAME NAME.

U. S. Coast and Geodetic Survey

THE NEW SURVEY SHIP "EXPLORER"

WITH COMPLETE SURVEYING EQUIPMENT, LAUNCHED IN 1939, REPLACED THE OLD SHIP.

W. Weidlich, U. S. Coast and Geodetic Survey

A COAST AND GEODETIC SURVEY CAMP IN SOUTHWESTERN ALASKA.

MUCH OF THE LIFE OF A COAST SURVEY FIELD ENGINEER IS SPENT IN SUCH ISOLATED OUTPOSTS GATHERING DATA FOR CHARTS WHICH HELP MAKE COASTAL WATERS SAFE FOR NAVIGATION.

R. R. Waesche, U. S. Coast Guard

BOGOSLOF ISLAND IN ERUPTION IN 1910.

A VOLCANIC CONE WITH BASE A MILE BELOW THE SEA IS CUT OFF AT SEA-LEVEL BY WAVE ACTION.

bars. Eighty miles seaward from the shore is the edge of the continental shelf. The seavalley of this great river of Asia is cut almost 70 miles back into the shelf and at least 3,000 feet deep. It is known on British charts as "Swatch of No Ground." The Indus River, 1,600 miles westward, empties into the Arabian Sea under similar circumstances and likewise a great seavalley is found off its mouth.

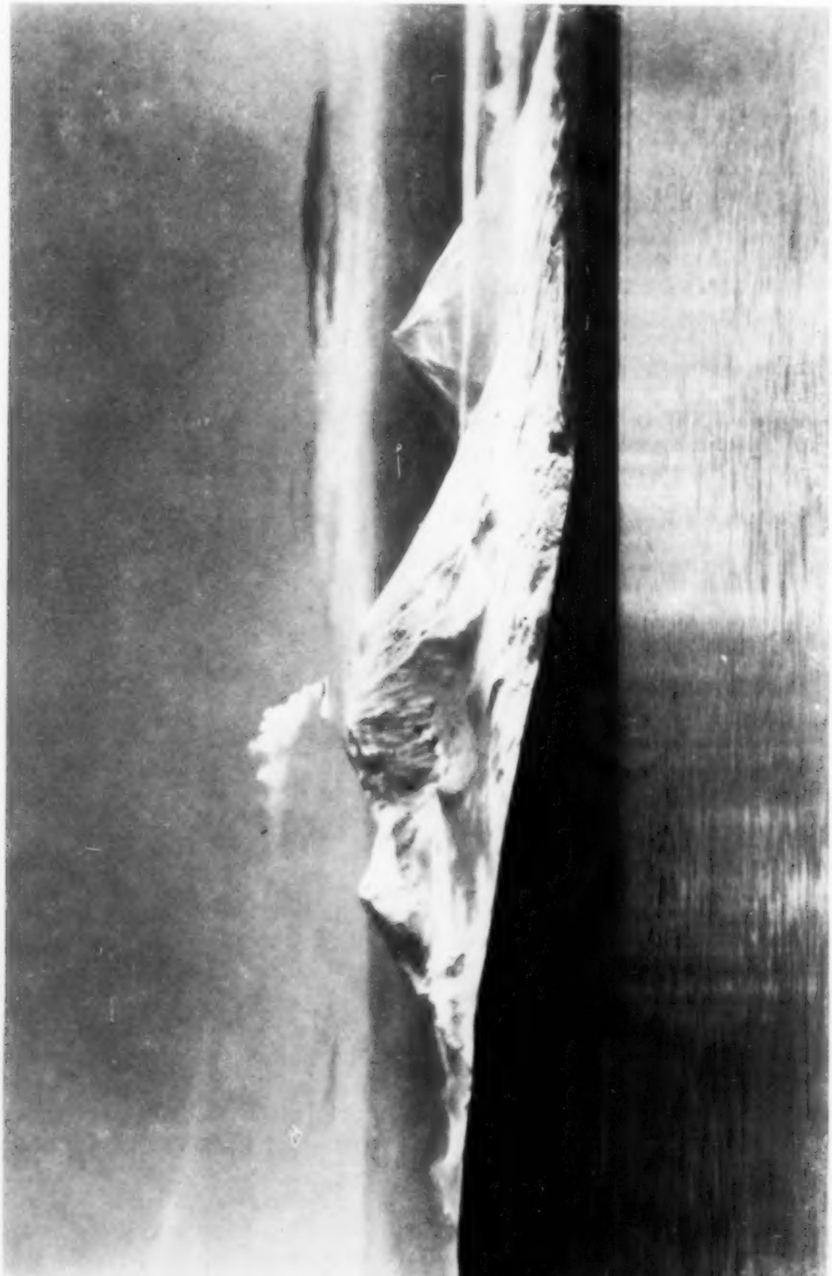
As for submarine mountains, a few examples are typical. A reconnaissance survey of the Gulf of Alaska, made by the Coast and Geodetic Survey ships en route to and from their working grounds during the past 15 years, shows that many large and impressive mountain ranges break the relief of the ocean floor in the Gulf. Prior to this discovery, the bottom of the Gulf of Alaska was occasionally referred to in geologic literature as one of the flat-bottomed "ocean basins." A few profiles plotted over some of these mountains show that they reach, in some instances, heights of 12,000 feet above the surrounding ocean bottom, although the summits are often half a mile or more beneath the surface. These preliminary profiles tell the experienced student of landforms that the submerged mountains have all the general characteristics of similar mountains we can see on the lands around us.

An intensive and accurate survey made around Bogoslof Island, the volcanic "Island of Mystery" in the Bering Sea just north of the Umnak Island, discloses that this small island, only about one mile in its greatest extent, is simply the top of a great volcanic cone more than five miles in diameter at the base, 5,000 feet below sea-level. This cone has been truncated by the sea to form a small submerged platform about two miles in diameter on which the island of Bogoslof stands. Each time the volcano erupts, as it has done a number of times within the historical period (since the last part of the eighteenth century), the small group of rocks forming the island are, of course, moved about on the submerged platform, causing the island to change shape and position and even to disappear completely at times. Here again the "stub" of this submarine volcano is almost identical in form and size with the equivalent lower sections of similar cinder cone volcanoes—Mounts Cleveland and Carlisle, for example, in the Islands of Four Mountains, not far to the west in the Aleutian Islands.

U. S. Navy

BOGOSLOF, FORMERLY ERUPTING, NOW LYING DORMANT.
FROM THE AIR THIS INSIGNIFICANT ISLAND SHOWS NOTHING OF THE GREAT VOLCANIC CONE HIDDEN BY THE SEA, BUT REVEALED BY THE SOUNDINGS.

Mendocino Escarpment, off the Pacific Coast of the United States, is probably the seaward extension of the San Andreas rift reaching offshore west of Cape Mendocino for at least 60 miles, and 6,000 feet high on the northern face. There are also numerous seavalleys off this coast, some of which are clearly the continuation of existing land drainage.



W. Weidlich, U. S. Coast and Geodetic Survey

PAVLOF VOLCANO, ALASKA PENINSULA, IN MAY, 1940.

THE VOLCANIC AND SEISMIC ACTIVITY OF THE PENINSULA AND THE ALEUTIAN ISLANDS ARE TYPIFIED BY THESE DORMANT VOLCANOES, AT LEAST ONE OF WHICH (BOGOSLOF) IS BENEATH THE BERING SEA.

After H. W. Murray

TYPICAL SUBMARINE MOUNTAIN RANGE IN THE GULF OF ALASKA.
VERTICAL AND HORIZONTAL SCALES ARE EQUAL.

such as the Monterey and Carmel Sea-valleys. Off the southwest coast of California the new surveys show extensive areas rich in what geologists term structural forms, that is, land shapes which are the result of large movements of sections of the earth's surface. Some remarkable examples may be found offshore between San Diego and Point Arguello. This is not surprising when it is realized that the same features control or dominate the relief of the adjacent land in Southern California. Even the last region mentioned has several prominent seavalleys, and it is also notable that each of the small islands off the coast of Southern California stands on its own small submerged platform similar in depth to those in the Philippine Islands and Alaska thousands of miles distant and in widely different latitudes. These submerged platforms are found in greater or less extent about almost every island or continent in the world, and the depths are remarkably uniform.

In the Gulf of Mexico the recent surveys show a different picture, but again not unexpected when the rather complete knowledge of the geology of the Coastal Plain adjacent to the Gulf is considered. The continental shelf here is unusually flat and smooth, and in places over 100 miles wide. The steeper declivity known as the continental slope is broken by some seavalleys, but less pronounced in character and less numerous than those of many other regions in the world. Here the landward heads of most of the submarine valleys seem to merge into the general slope between depths of 200 and 300 fathoms with a notable exception. The most important of the known sea-

W. R. Porter, U. S. Coast and Geodetic Survey

MOUNTS CLEVELAND AND CARLISLE OF THE ALEUTIAN ISLANDS.
MT. CARLISLE AT RIGHT, EXACTLY ONE MILE HIGH, IS HERE HIDDEN BY THE CLOUDS IN ALMOST THE SAME PROPORTION AS BOGOSLOF IS COVERED BY THE SEA.

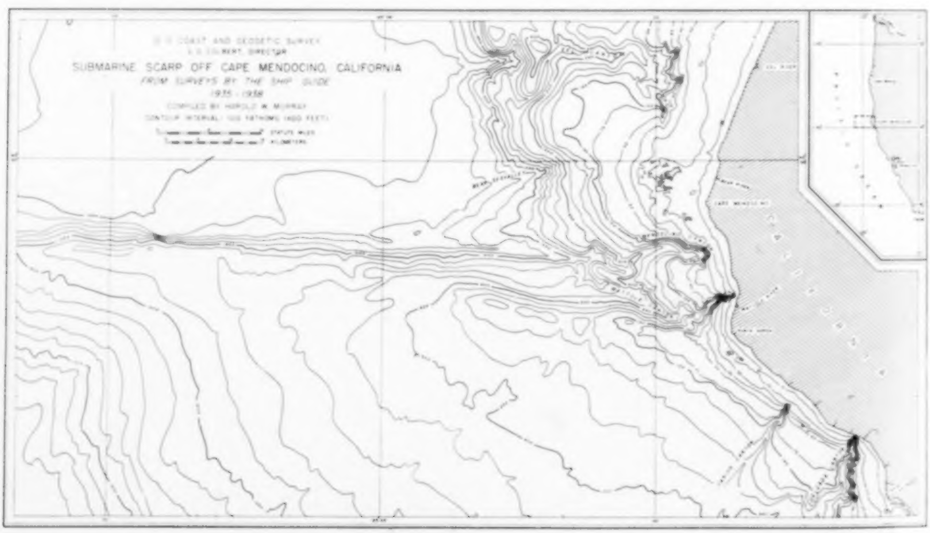
THE VOLCANIC AND SEISMIC ACTIVITY OF THE PENINSULA AND THE ALEUTIAN ISLANDS ARE TYPIFIED BY THESE DORMANT VOLCANOES, AT LEAST ONE OF WHICH (BOGOSLOF) IS BENEATH THE BERING SEA.

valleys in the Gulf of Mexico indents the shelf for about 30 miles just southwest of the present Mississippi River. Its exact connection in geologic time with the present Mississippi River is obscure, as is the case in other similar examples.

The continental margin of the Atlantic Coast of the United States is now well surveyed over about half of its total extent, *i.e.*, between Cape Hatteras and Georges Bank, 150 miles east of Cape Cod. The shelf is also flat to depths of about 500 feet, but it is rich in forms similar to those being shaped by wave and tidal current forces close along the adjacent shore to-day.

The continental *slope* north of Cape Hatteras, on the contrary, is heavily eroded into many deep canyons like those made by streams running down similar steep slopes in mountainous regions on land. Outstanding of these Atlantic Coast canyons is the Hudson, 3,600 feet deep in its deepest cut, which is connected to the present Hudson River by a shallow submarine channel extending 100 miles across the shelf. The form of this shallow channel resembles the channels now submerged in Chesapeake and Delaware Bays to a striking degree. The differences in characteristics of the channel or shelf features and those of the slope are apparent from profiles registered by the depth recorder as the surveying ship crossed the features. Between the seaward end of the Hudson Channel and the deep seavalley or canyon cut 17 miles back into the continental shelf is an old delta covering over 500 square miles and at a depth of about 43 fathoms (258 feet).

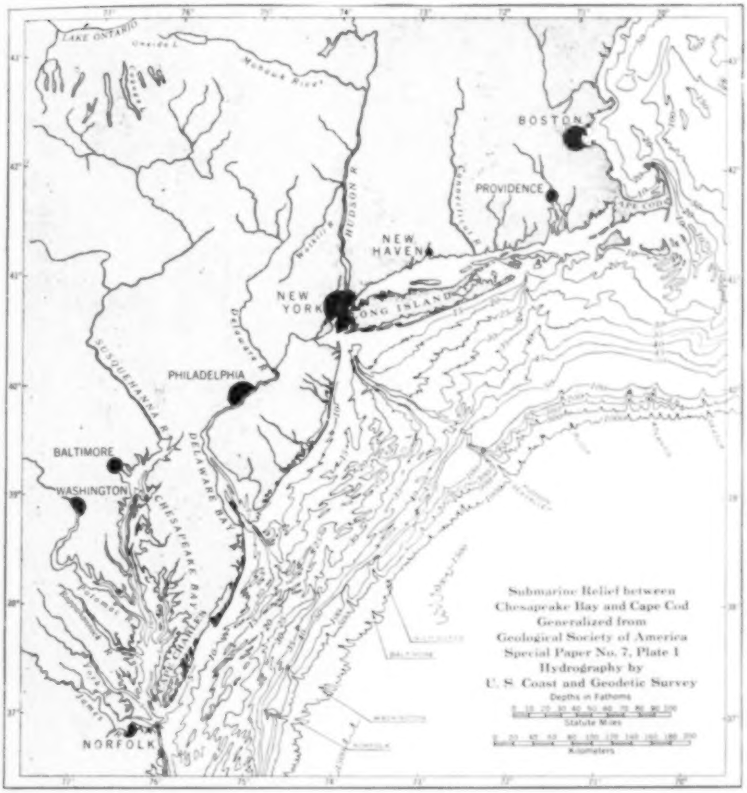
The surface of the continental shelf near Nantucket Island, where strong tidal currents run continuously, is ruffled by large "submarine dunes" or sand waves. Their profiles are likewise well known through the depth recorder, and their varied forms tell the physiographer that a generous supply of fine sand is here being moved about on the sea floor by tidal currents and shaped into large sand waves not unlike some of the great dunes of Imperial Valley or the Sahara.



From H. W. Murray

THE MENDOCINO ESCARPMENT

PROBABLY THE SEAWARD CONTINUATION OF THE GREAT SAN ANDREAS FAULT OF CALIFORNIA.



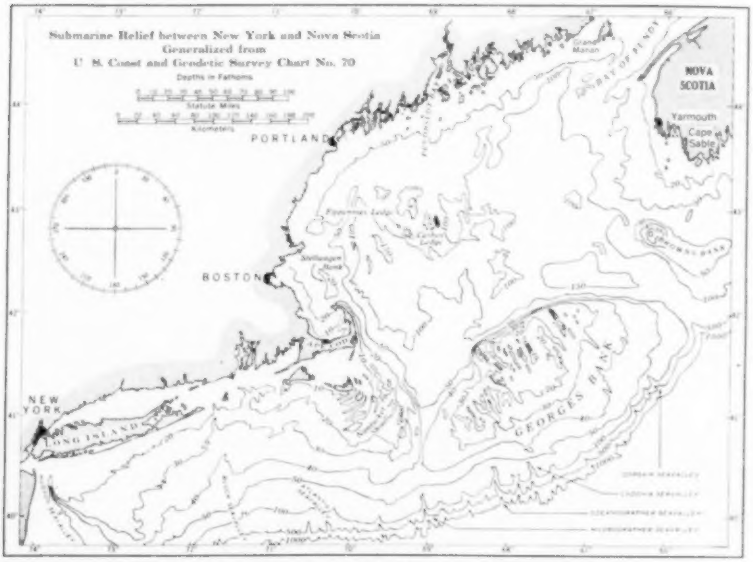
After Veatch and Smith

SUBMARINE RELIEF BETWEEN CHESAPEAKE BAY AND CAPE COD.

THE BROAD CONTINENTAL SHELF BETWEEN CHESAPEAKE BAY AND CAPE COD SHOWS THE REMAINS OF TERRACES, ESTUARIES AND CAPES FROM FORMER AND LOWER STANDS OF SEA-LEVEL. THE DEEP CANYONS OF THE CONTINENTAL SLOPE ARE IMPORTANT FACTS IN EARTH HISTORY.

One of the largest observed is over 60 feet high and 1,000 feet horizontally between crest and trough. Similar conditions were found in the North Sea by the Netherlands hydrographers in 1935 along the coasts of the Low Countries where strong tidal currents and sandy bottoms are also found. Fortunately, a complete report of this excellent work has been published.

The Gulf of Maine is only partially surveyed, but the first season's results show, as is to be expected, that the bottom relief here is unique. In the basins or depressions between about 540 to 900 feet, the depth recorder profiles reveal that a layer, sometimes several layers, of silt cover the sea bottom. In some places the silt is as much as 60 feet thick. The automatic depth recorder shows this plainly. Whenever the difference in radiation resistance of the layers of water becomes great enough, as happens in the case of the silt-laden bottom layers, an echo is received from the boundary between the layers. The same principle is used in seismic prospecting to determine the thickness of sediments thousands of feet down in the earth. In echo sounding, however, relatively little energy from an electrical oscillator is used to create the impulse causing

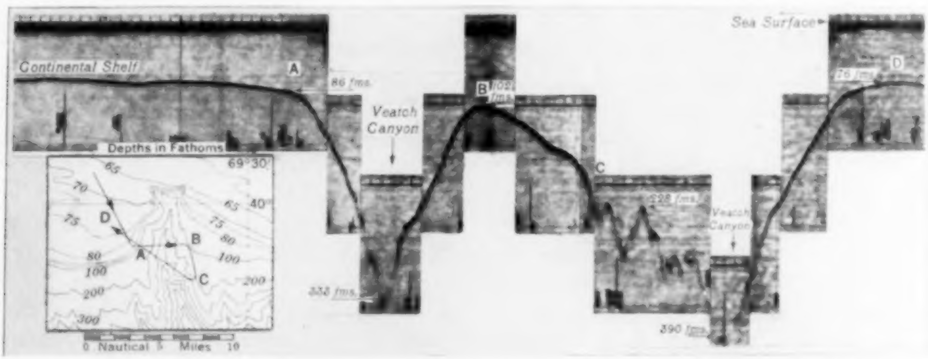


THE VARIED SUBMERGED LAND FORMS

OF THE GULF OF MAINE AND GEORGES BANK ARE IMPORTANT CLUES TO EARTH HISTORY. SELECTED CONTOURS INDICATE THE MAJOR FEATURES ONLY. SURVEYS OF THE REGION ARE INCOMPLETE.

echoes; whereas in seismic reflections a considerable charge of explosive may be necessary.

Most of the bottom of the Gulf of Maine is irregular and broken as compared to the continental shelves along other coasts at approximately the same depths. The Gulf is practically a mediterranean sea because the eastward extension of the Coastal Plain cuesta forms a great submerged tongue known as Georges Bank, and this bank acts as a barrier to the waters deeper than about 270 feet. Except for the two channels between Georges Bank and Nova Scotia the Gulf may be considered as a closed



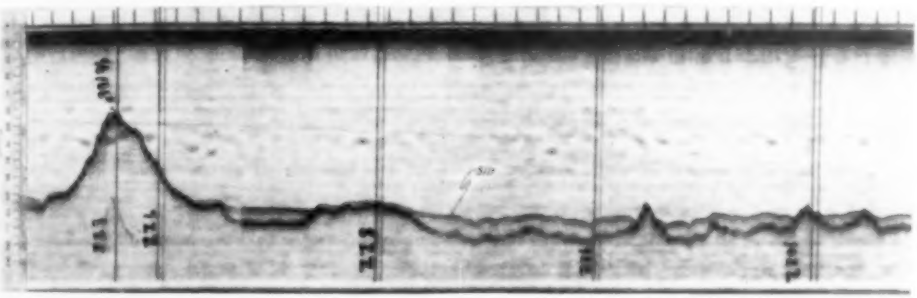
ACTUAL ECHO SOUNDING RECORD ACROSS HEAD OF VEATCH SEAVALLEY

95 MILES SOUTH OF NANTUCKET ISLAND, SHOWING FLAT CONTINENTAL SHELF AT LEFT AND AT RIGHT THE V-SHAPED PROFILE CHARACTERISTIC OF CONTINENTAL SLOPE CANYONS. A, B, C, D ON INSERT AND PROFILE SHOW ROUTE OF SHIP CROSSING AXIS OF VEATCH CANYON TWICE. THE VERTICAL EXAGGERATION OF SCALE IS 13 TO 1.

body of water to waters deeper than 45 fathoms. It is therefore understandable why here thick layers of silt are collecting in the basins which are not exposed to the force of the tidal currents sweeping over the banks and the continental shelves.

Two notable observations might be mentioned. Fippennies Ledge is almost as flat as a table at a depth of about 228 feet, while Cashes Ledge, 20 odd miles east, rises in rocky irregular form to within 30 feet of the surface without any prominent trace of the stand of the sea that may have been responsible for the wave-cut top of Fippennies Ledge. It would be unwise to draw positive conclusions on the history of this region until the entire Gulf has been well surveyed; but because the great Glacial ice caps probably advanced over the Gulf as far as Georges Bank, the area is undoubtedly one of the most significant and fruitful regions in the world to the student of geomorphology.

One other region which will be embraced by the new surveys and which possesses to some degree a character of its own is the shelf and slope off southeastern United States. In this area the Gulf Stream bends close in shore and the continual flow of this vast and powerful current has doubtless been largely responsible for some of the conditions found here. Surveys of this area are also only partially complete, but a few of the depth recorder profiles made during surveys of the coast of South Carolina show some unusual forms, and the survey has progressed far enough to indicate that the flat part of the shelf does not break so abruptly to the stream-eroded type common to the continental slope north of Cape Hatteras. The change is more gradual and the slope itself more gentle. Near the seaward edge of the shelf several distinct depressions several miles in diameter and 200 feet deep have been found. One of them is at a depth of about 750 feet. A number of small plateaus or mesa-like features were revealed, and in one instance a distinct but small fault scarp was noted in depths of about 180 feet.



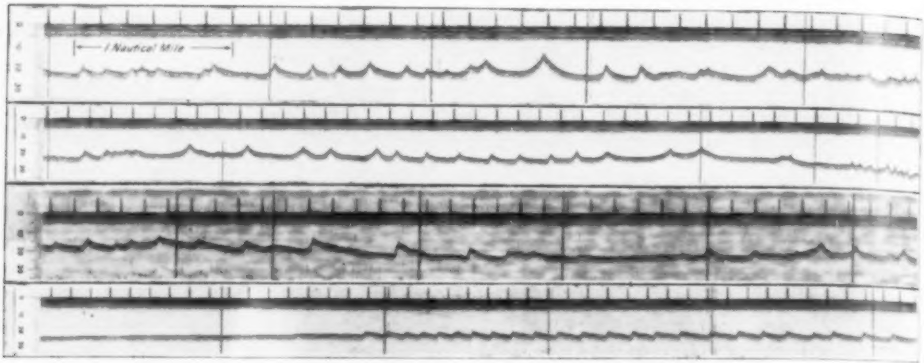
U. S. Coast and Geodetic Survey, 1940

ECHO SOUNDING RECORD OF SECTION OF THE GULF OF MAINE.

SILT COVERS LARGE AREAS OF THE GULF AS SHOWN BY THE SMOOTHER UPPER TRACE THROUGH WHICH THE BOTTOM IRREGULARITIES SOMETIMES PROJECT. VERTICAL EXAGGERATION ABOUT 13 TO 1.

From the few examples briefly described, I think one may draw a few conclusions, most of which have been stated in part by a number of writers in this field during the past century, among whom are Dana, Hull, Spencer, Lindenkohl, Davidson, Shepard and Veatch.

Summarizing briefly, it is obvious that submarine relief, from mountains to valleys, is quite like the landforms we see on the land above the sea. The most striking change in characteristics of submarine relief occurs at the edge of the continental shelves. The continental



U. S. Coast and Geodetic Survey records, 193

DEPTH RECORDER PROFILES OF SAND WAVES ON NANTUCKET SHOALS.

STRONG TIDAL CURRENTS WORK THE SAND INTO "WAVES" IN FORM SIMILAR TO SAND DUNES OF DESERT AREAS. SCALE AT LEFT SHOWS DEPTH IN FATHOMS. LARGEST SAND WAVE (SHOWN IN THE TOP RECORD) IS 60 FEET FROM TROUGH TO CREST.

slopes in many places throughout the world carry the unmistakable imprint of stream erosion; and we know the deep, characteristic V-shaped valleys are commonly formed by rivers flowing on land above the sea. The flat continental shelves, of such remarkable uniformity in depth all over the world, are due to the wave and current planation resulting from a slowly shifting sea-level between the limits of the present shelf depth. The general characteristics of some of the submarine mountains appear to be those of weathered mountains—not marine depositional forms. The submarine river erosion patterns found on many of the continental slopes are so definitely connected with many major river valleys on land, and the submarine counterparts of such streams are usually so youthful in physiographic character compared to their adjacent land valleys, that one may say it further confirms the idea that the continental slopes have at some time been exposed to subaerial erosion by the seaward continuation of many of the major rivers now flowing into the sea. The continents are, of course, more maturely eroded than the submarine continental slopes due to longer exposure of the former to subaerial processes than the submerged slopes which have been truncated by the sea at the present shelf depths. The geologic age or ages of the drowning of the slope relief is not yet certain, but present evidence is strongly in favor of Pleistocene or Ice Age time. One significant point aiding the more exact dating of the canyons is the fact that the Hudson and Mississippi Seavalleys are cut much farther into the continental shelf than any others on the Atlantic and Gulf Coasts of the United States. It is rather well established that both these streams received during the recession of Wisconsin ice, some tens of thousands of years ago, considerably more water than they at present discharge into the sea; the Hudson through the Mohawk Channel and the Mississippi through the St. Croix, Illinois, Wabash and Lake Agassiz drainage. The *cause* of such great changes between land and sea is even more obscure and it is likely to remain so for some years to come.

I think, however, the future course is clear. If the existing mass of physiographic evidence is not satisfying proof of the first of these ideas, namely, that the continental slopes were actually exposed by a withdrawal of the sea to the

extent indicated (at least 10,000 feet), conclusive evidence will most likely be found when thorough surveys of the Mediterranean Sea, the Red Sea, Sulu Sea and other similar basins are completed. The second—when did such an event occur?—may be approached most profitably by extension of geophysical and geological exploration of the submerged continental borders, that is, by the collecting of core samples and careful geologic analyses, and submarine seismic exploration in such work as has recently been done in this country under the sponsorship of the Geological Society of America and the National Research Council, and in England through the Royal Society and the International Geodetic and Geophysical Union.

In the meantime it seems important to scrutinize more carefully the fundamental facts supporting certain geological and biological ideas which do not harmonize with the story told so plainly by the forms of the lands beneath the sea.

EFFECTS OF THE WAR ON BRITISH EDUCATION

These changes which are to come in the secondary education system will require changes in the university system itself. It will require changes in method of accoutrement, and it will require some changes in the preliminary work inside of the universities. So, although I can not say how or in what way the solution will be found, I can, in the terms of the declaration of the President of the Board of Education, give you a picture of the way in which our minds are working. We are determined that we shall have a more flexible educational system, a system that is fitted to the educational requirements of the whole child population of the country, and not to any minority judged by any social or any ability standards. We shall have to reconstruct and reorganize our university groups. We shall have to reabsorb student populations with very unusual experiences. We shall have to absorb the whole academic population. But I am confident that when the total effects are seen, perhaps the most important of all the effects of the war on the educational life of the country will be those that Dean Holmes referred to—the effects of the war itself on the population of my country.

Reading the papers, you would come to regard England as an interesting interconnection of rubbish heaps, the results of air raids. It is true there are many such rubbish heaps, there are many scars, there are many wounds, but what strikes you most about life in England is its normalcy, its continuity, its sanity and its stability. People are looking things extremely squarely in the face. They are recapturing lost values. They are finding that to be true to your standards of your job, whatever sort it may be, is the only thing that really matters, that carries you through in your time of crisis. Mothers of families, air raid workers, women called to munitions work to which they are entirely unaccustomed, young men called to serve in a variety of different military, naval and air forces; and many numbers of people called into different kinds of public work, entirely untrained, dug out by the roots, often going in physical fear—all finding in their work the peace of mind, the capacity for action, the capacity for clear thinking and a resolute determination to face all problems that confront them squarely on their merits and not on the basis of any "ism." It is against that background that these educational changes . . . are being worked out.

The day is not too far distant before this type of quiet work of reconstruction, which I bid you to notice is already beginning, can come to fruition. I am sure that just as the people of England are demonstrating in their daily lives that a great tradition can be molded and built to meet the great requirements of the new and strange horror of war, so the great traditions of the English educational system which was inevitably in its origins a minority system is capable of being molded, its values unimpaired, its essential spirit kindled and broadened to meet the requirements of a whole new generation and a new and rekindled people.—*Noel F. Hall, Educational Record, July, 1941.*

DISTRIBUTION OF TORRENTIAL RAINFALLS IN THE UNITED STATES

By Dr. STEPHEN S. VISHER
PROFESSOR OF GEOGRAPHY, INDIANA UNIVERSITY

WHAT counts as to rainfall is the actual amount that falls and when it falls, not averages. Plants can not grow in response to "expected or probable" amounts. Places which receive the same annual amounts of rain may have quite different conditions for plant growth because of differences in the time of fall as to season and as to intensity.

Just as there are recognized in the United States three chief types of annual precipitation totals (humid, semi-arid and arid) and three types of seasonal totals (largely during the cooler season, chiefly during the warmer months, and "uniform"), so are there three types of rainfall, gentle or light, moderate and torrential. Drizzles are the extreme type of gentle rains, while "cloudbursts" which yield several inches of rain in an hour are the extreme type of torrential rains.

Although all parts of the United States receive some rainfall of each of these three types, there are noteworthy regional contrasts in their relative importance. Gentle rains are characteristic of the cyclonic Lows which bring most of the rainfall of the North and much of that of the cooler months in the South.

The northern half of the country has an annual average of more than twice as many light rains as the southern half, and the northeastern region more than three times as many as the Southwest. The greatest number in the East, about 100 per year, occur in New York and Pennsylvania. The fewest, less than 20 per year, occur in southeastern California and Arizona. Of moderate rains (.26 to 1.0 inches in a day), the eastern fourth of the country has about 40 per year, nearly twice as many as the western half. An area centering in West Virginia has more than five times as many as the arid Southwest.[1]

TORRENTIAL RAINS

Several types of rainfall are classed as torrential. First may be considered the regional contrast in rainfalls of one to two inches per day. The northeastern states have such rains an average of less than twice a year while the southeastern states have an average of more than six a year.[1]

Of rainfalls in excess of two inches in a day, the extreme North and most of the West has less than one a year while the Gulf Coast has an average of more than four a year.[1]

Of rainfalls of over one inch in an hour, the South has an average of more than three a year while the northern part of the North and all the western half of the country has less than one such rain a year. Much of the Gulf Coast has more than six such rains a year.[1]

The maximum precipitation in one hour received at the leading Weather Bureau stations during a 20-year period was less than two inches in the western half of the country and in the northern part of the northeastern quarter, but was more than four inches near the Gulf Coast.[1]

A large mass of data on torrential rainfall has been organized by the senior drainage engineer of the U. S. Bureau of

[1] J. B. Kincer, "Precipitation in the U. S." Atlas of American Agriculture, U. S. Department of Agriculture, Washington, 1922.

Agricultural Engineering.[2] The records analyzed are of the rainfalls which occurred in periods ranging from five minutes to 24 hours, during 30 years at the 208 U. S. Weather Bureau stations which possess recording rain gauges. Yarnell published tabulations of the data and presents his generalizations therefrom in more than 70 maps. Summaries of the regional contrasts are appropriate here.

The amount of rain which falls in the sharpest brief rains varies regionally in a systematic manner, the largest totals occurring along the Gulf Coast, the smallest occurring in the arid parts of the West; the northeastern part of the country is intermediate. Of the most common type mapped, the amount to be expected in five minutes in half of the years, the totals in the arid West are less than .15 inches, in the Northeast about twice that amount, and along the Gulf at least three times that amount, or more than half an inch. In each decade, some one five-minute rain yields about a quarter inch in the West, nearly half an inch in the Northeast, and about .65 inches near the Gulf. The maximum rainfalls in five minutes reported are 1.9 inches at Taylor, Tex.; 1.2 at Augusta, Ga.; and 1.0 at Terre Haute, Ind., Harrisburg, Pa., and Portland, Me.

Rains yield ten-minute totals of somewhat more than an inch along the Gulf once a decade but less than a half inch in the western fourth of the country; in the Northeast, the totals are about intermediate. The maximum rainfalls in ten minutes reported are 1.9 inches at Taylor, Tex., 1.7 at Tampa, Fla., 1.4 at Valentine, Neb., Portland, Me., and Northfield, Vt.

An inch of rain falls in fifteen minutes once a decade at the Northeast, less than half that amount in the far West, and about 1.5 inches near the Gulf. The maximum rainfalls in fifteen minutes reported by Yarnell are 2.3 inches at Pensacola, Fla., and Taylor, Tex., 2.1 at Augusta, Ga., and 2.0 at Houston, Tex., and Tampa, Fla. A rainfall of three inches in 15 minutes is officially reported, however, from Holland, S. C. (8/28/96), and one of 3.9 inches from Galveston, Tex. (6/14/71).

Rainfalls of more than two inches in a half hour occur each decade in the Southeast, but the half hour totals to be expected each decade are less than half an inch in part of the Northwest and 1.25 inches in the Northeast. The maximum rainfalls in a half hour reported by Yarnell are 3.6 inches at Pensacola, Fla., 3.1 at Kansas City, Mo., 3.0 at Anniston, Ala., Hatteras, N. C., and Thomasville, Ga., 2.9 at Brownsville, Houston and Taylor, Tex., and Tonapah, Nev. Higher records reported in the *Monthly Weather Review* are 9.2 inches at Guinea, Va. (8/24/06), 8.0 inches at Taylor, Tex. (9/9/21) and 4.1 at Biscayne, Fla. (3/28/74).[3]

In an hour, the Gulf Coast receives each decade a downpour of about three inches, the northern part of the East one rain of about half that total, and the West one of one third that total. The maximum rainfalls in an hour reported by Yarnell are 5.3 inches at Galveston, Tex., and Hatteras, N. C., 4.7 at Brownsville, Tex., and Kansas City, and 4.3 at Key West, Fla. Higher official records reported elsewhere include, in addition to those reported under 30 minutes, 5.8 inches at Oakdale, Neb. (7/16/20), 6.9 at Tridelphia, W. Va. (7/19/88) and 8.0 at Ft. Mojave, Ariz. (8/28/98).

The regional contrasts in the totals of rain to be expected in periods with a length of five to sixty minutes are, therefore, similar. For each type, the Gulf

[2] D. L. Yarnell, "Rainfall Intensity-Frequency Data." Miscel. Publ. No. 204, U. S. Department of Agriculture, Washington, 1935.

[3] Some of these extra records were assembled by J. R. Theaman in a booklet "Heavy Rainfall Records," Indianapolis, 1931.

Coast receives totals of about three times as great as the Far West and approximately twice as great as the Northeast.

The regional disparity in the totals of rainfall received in short periods increase with the length of the period. For example, 2-hour rains yield three inches of rain every other year along the Gulf Coast, but such rains happen less than twice a century near the Canadian border, or in the western third of the country. The totals received once in two years are for the Northeast about an inch, and for the Northwest less than a half inch. Two-hour rainfalls in excess of four inches are reported from 43 of the 203 widely scattered American stations, distributed as follows: in the Northeast (21 states) five, in the West one, in the Upper South (Oklahoma to Maryland) eleven, and in the Deep or Lower South (the Gulf States, Georgia and South Carolina), 26. The maximum falls at those stations in those thirty years were 7.5 and 7.1 inches in Texas and Florida. Several greater totals have been officially reported from other stations, for example, 11.5 inches at Campo, Calif. (8/12/91), 8.0 inches at Ft. Mojave, Ariz. (8/28/98), Tama, Ia. (8/2/29) and Taylor, Tex. (9/9/91).

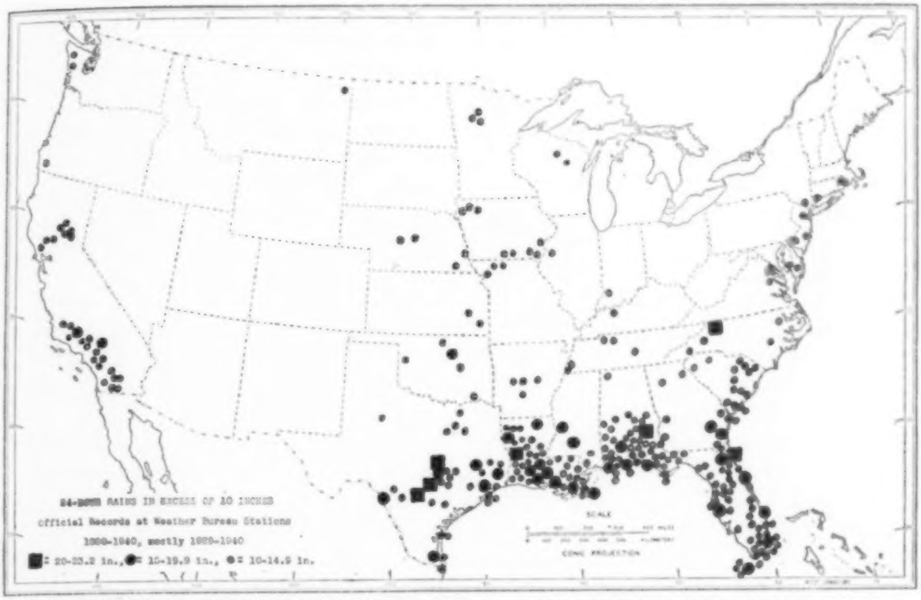
Four consecutive hours of hard rain occur much more rarely in the North and West than in the South. During each average five years the Gulf Coast has at least one four-hour rain yielding more than four inches. Such a rain does not occur, Yarnell reports, oftener than about once a century in the Northeast. The maximum to be expected for this interval is about two inches at the northern border of the country and less than 1.5 inches in much of the West. Of eight-hour rains, the Gulf Coast normally has one each decade which yields six inches, while the North receives in a century a maximum rainfall of less than about five inches in eight hours, and the West a maximum of less than four inches. During each average decade, the maximum eight-hour rain is less than 3.5 inches in the Northeast and less than 2.5 inches in the West.

The regional contrasts in sixteen-hour rains are of similar proportions: The Gulf Coast receives more than twice as much rain as the Northeast, and more than three times that of the West.

In some one 24-hour period, the Gulf Coast receives each average decade a rainfall of more than seven inches, or more than twice as much as is received in the Northeast, and more than three times as much as in the West. The totals for the heaviest 24-hour fall in a century display still greater contrasts, the Gulf Coast receiving about three times as much as the Northeast and more than four times as much as most of the West. A 24-hour rain of six inches is to be expected twice a decade near the Gulf but less than once a century in most of the Northeast. The greatest 24-hour rainfall of each average five years is less than three inches in much of the Northeast, and is less than two inches in much of the West.

A Special Study of 24-Hour Rains in Excess of Ten Inches

Evidence supplementary to the data just summarized has been sought in numerous sources. One highly suggestive new body of data deals with rainfalls of ten inches or more in 24 consecutive hours. A total of 293 American records of such rains have been culled from the official local records. The states having most such official records are Florida 68, Louisiana 44, Alabama 38, Texas 32, California 25, and South Carolina 15. The seven official records of more than 20 inches falling within 24 consecutive hours are as follows: 23.2 inches at New Smyrna, Fla., October 9–10, 1924; 23.1 inches at Taylor, Tex., 9/9–10/21; 22.2 inches, Altapass, N. C., 7/15–16/16; 21.4 inches, Alexandria,



DISTRIBUTION OF HEAVY RAINFALLS IN THE UNITED STATES

La., 6/14–16/86; 20.4 inches, Smithville, Tex., 6/29–30/40; 20.1 inches, Montell, Tex., 6/28/13; 20.0 inches, Elba, Ala., 3/15/29. Records of 18 or 19 inches in 24 hours are held by four other Weather Bureau stations in Louisiana, two in Texas, and one in Georgia.

Many of these rainfalls of more than ten inches in 24 hours fell in less than 24 hours. For example, Beaumont, Tex., got 13.5 inches in three hours (5/18/23) and Taylor, Tex., received 10.3 inches in three hours, and 23.1 inches in fifteen hours (9/9/21).

The location of the records are shown on the first accompanying map, where the amount of rain is indicated by the symbol used. The squares represent the records of twenty inches or more of rainfall in 24 hours, the large dots locate the rains of 15–19.9 inches, and the circles those of 10–14.9 inches. Because parts of some southern states have had numerous such rains, the lack of space prevents the precise locating of some of the circles. For example, the southern half of Alabama has had 37 such rains, 13 of them in the small southwestern projection. Consequently some of the circles are placed in the Gulf. Other crowded areas are in southern and eastern Florida and in southeastern Texas.

This first map makes conspicuous the fact that the southern part of the South has had many rains in excess of ten inches in 24 hours, and that there is a rapid decline in numbers within a hundred miles or so of the coast not only along the Gulf but along the Atlantic and Pacific. In the interior, there is a progressive northward decline in the number of these very hard rains except for local increases in the Southern Appalachians and near the Balcones Escarpment of the Texas Plateau.

The following analysis of the storms which brought rainfalls in excess of ten inches in 24 hours is of interest. Of 202 storms which brought such rains to one or more Weather Bureau stations, 162 occurred in the South, 24 in the North, 16 in the West. Of the 39 storms which

yielded more than 15 inches in 24 hours, the South had 37, California two. As to season, the summer had 82 rains of over ten inches in 24 hours, autumn 75, spring 29, and winter 16. As to month, September had 47, July 33, August 27, June 22, October 18, March 13, November ten, April and May each eight; the three winter months each about four. Of 16 such winter rains, the South had seven, California eight, Washington one. Of 29 ten-inch spring rains, the South had 23, California five, and Missouri one. Of 82 summer rains of this amount, the South had 62, the North 19, Montana one. Of the 75 autumn rains the South had 67, the North seven, California one. Thus of the North's rains in excess of ten inches in 24 hours four fifths occurred in summer, in contrast to about one third in the South.

Frequency of Ten-inch Rains

The sharp regional contrast in the number of exceptionally heavy rains indicated by this map is made even more clear by an analysis. The map shows all the records, some of them established sixty years ago, when Weather Bureau stations were less uniformly distributed and conducted than at present. The analysis now to be presented concerns the records during a recent ten-year period (1929–1937 and 1939).

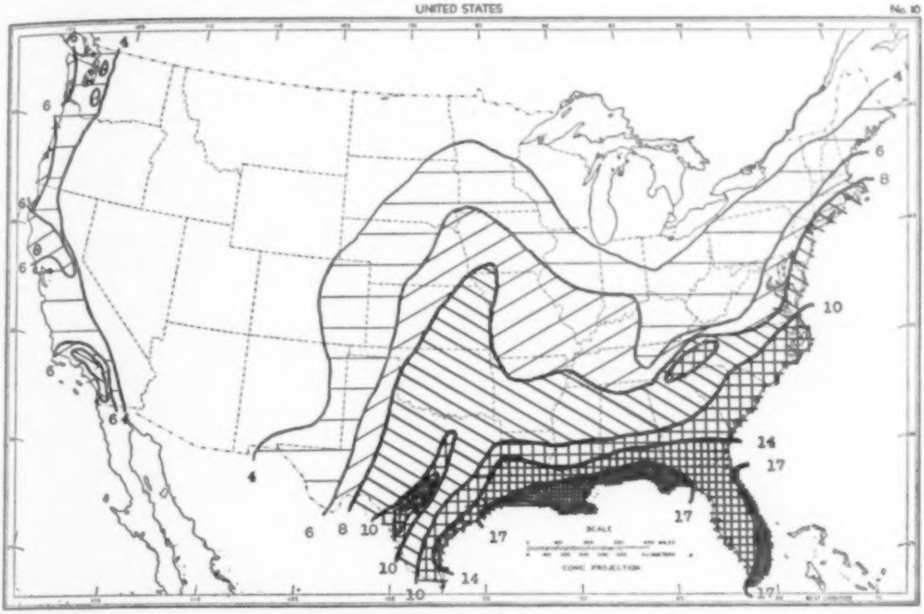
During that recent decade, the Deep South, that is, the five states bordering the Gulf plus Georgia and South Carolina, had eight official records of rains of more than fifteen inches in 24 hours. The "Upper South" (from Oklahoma to Maryland) had one such rain in that period, but the West and North had none.

The Deep South had 47 official records of rains of 10 to 14.9 inches in 24 hours in the decade. The Upper South had eight, the North four, two each in Missouri and New Jersey. The West had one.

In proportion to area, the Deep South with 55 had about ten times as many records of rains of over ten inches in 24 hours in the decade as did the Upper South, and more than a hundred times as many as did the northeastern 21 states. No such rain was recorded from the Rocky Mountain States during that ten-year period and only one from the Pacific States.

The second map herewith shows the amounts of rainfall which may reasonably be expected in the 24 hours of heaviest rainfall of a fifty-year period. It serves as a sort of summary of the foregoing data on the distribution of great rainfalls and their frequency.

Thus it is apparent that these data supplement other evidence in indicating that there are systematic regional contrasts in the United States in torrential rainfalls. In brief, the United States may be divided into four great regions with respect to the amounts of rainfall records in short periods. These regions are: The Deep South (the Gulf States plus Georgia and South Carolina), the Northeast, the West, and a zone between the Deep South and the Northeast consisting chiefly of the Upper South (Oklahoma to Maryland). The Deep South receives an average of more than three times as much rainfall in short periods of exceptionally hard rain as does the West, about twice as much as the Northeast and about one and a half times as much as the transition belt of the Upper South. It not only receives much larger maximum falls in such hard rains but receives very hard rains much more frequently than does the North and West. For example, three inches of rain falls within two consecutive hours once in two or three years or oftener, on the average, close to the Gulf, once in two to five years in most of the Deep South, once a decade in the Upper South, once a half century in the southern part of the North, but only about once a century, Yarnell re-



AVERAGE MAXIMUM 24-HOUR RAINFALLS

INCHES TO BE EXPECTED IN THE HEAVIEST RAIN OF 50 YEARS.

ports, along the Canadian border and in the West. In other words, such rains are about fifty times as common at the southern border of the eastern half of the United States as at the northern border. The regional contrast is even larger for rainfalls of greater amounts: rainfalls of five inches in eight consecutive hours are unknown in most of the North, but near the Gulf occur twice an average decade.

Reasons for the Regional Contrast in Torrential Rainfalls

Just as there are meteorological reasons for the contrasts in annual and seasonal totals of rainfall, so are there reasons for the regional contrasts in torrential rainfall. Three influences cooperate to produce most of the differences. These are (1) variations in the availability of abundant atmospheric moisture; (2) variations in the intensity of convectional atmospheric disturbances, the great cause of thunderstorms; and (3) variations in the intensity of cyclonic storms. The most important cyclonic storm in the production of exceptionally heavy rains is the tropical cyclone which is called a hurricane if it is accompanied by violent winds, but which frequently brings torrential rains even if its winds are moderate. A fourth factor of local influence in causing the regional contrasts in the number and size of the torrential rains are differences in topography. Upon the windward side of the Southern Appalachians and Pacific Coast Ranges there are occasional hard rains of the so-called orographic type.

The availability of atmospheric moisture varies with the accessibility to sources of moisture, chief of which is the ocean. Hence the air over areas remote from the sea usually contains less moisture than that over coastal areas and, having less, it can yield less rainfall when cooled sufficiently to cause precipitation. Important in this connection is

the fact that there is much more active evaporation from warm bodies of water such as the Gulf of Mexico than from cool ones, such as the Great Lakes. As warm air can include much more moisture than can cool air, it can give up more when sufficiently cooled. Moreover, in warm regions such as the Gulf States, the air often is warm to a much greater height than is usually true in the North. These several conditions powerfully influence the distribution of torrential rains, causing a northward and interior decline. The less rapid northward decline in the Mississippi Valley than between there and the eastern mountains is partly due to their greater accessibility to the Gulf of Mexico, the great source of moisture for most of the eastern half of the United States.

Thunderstorms, the immediate cause of most of the sharp torrential rains, are more than twice as numerous in the South as in the North; the Gulf Coast east of the Mississippi has more than three times as many as the Canadian border.[4] In the West, thunderstorms are less common than in the Northeast, and the number which yield much rain to lowlands is still smaller.

Tropical cyclones, the cause of many of the greater rains, are relatively numerous along the Gulf and South Atlantic coasts. An average of about 20 cyclonic disturbances impinge upon the Gulf of South Atlantic coast each year.[5] Only a few are hurricanes, but some of the heaviest rains have come from slow-moving tropical cyclones which do not have strong winds. Tropical cyclones commonly lose much of their intensity, or even die away, shortly after leaving the sea. This latter fact is an important cause of the abrupt decrease inland in the number of rains in excess of ten inches in 24 hours.

Some Results of the Torrential Rains

Torrential rains necessarily result in much runoff and flooding, and the larger rains usually do considerable damage. For example, the rain of 8 to 20 inches in 24 hours on June 29–30, 1940, in southeastern Texas was estimated by the local Weather Bureau official to have caused immediate damage exceeding $700,000, of which $455,000 was to crops, $85,000 to live stock, and $200,000 to buildings, roads and bridges, etc. Seven people were drowned. Even greater was the damage caused by the exceptional rain of March 14–15, 1929, in southeastern Alabama when 8 Weather Bureau Stations recorded from 10 to 20 inches of rain in 24 hours. Several towns were badly flooded, the water standing 10 feet deep in parts of Elba. The damage was officially estimated to have been more than $3,750,000, not including suspension of business.

Less spectacular than flooded towns, valleys and fields, but much more serious in the aggregate is the damage to the soil by exceptionally heavy rains. The sloping land of the South has suffered such extensive erosion that already more than 40 million acres which were formerly farmed have been abandoned because much of the topsoil is gone or numerous deep gullies have been formed. Soil erosion is especially serious in the South not alone because the chief crops grown there (cotton, corn, tobacco, peanuts, vegetables) are row-cultivated or intertilled and hence afford little protection to the soil, but also because torrential rains are exceptionally numerous and intense there. Thus the distribution of torrential rainfalls in the United States helps to explain the relative amounts of soil erosion and of poverty.

[4] W. H. Alexander, *Monthly Weather Review*, 63: 157–158, 1935.

[5] S. S. Visher, *Monthly Weather Review*, 58: 62–64, 1930. *Idem: Geographical Rev.*, 15: 106–114, 1925. I. M. Cline, "Tropical Cyclones," New York, 1926. I. R. Tannehill, "Hurricanes," Princeton, N. J., 1938.

SYNTHETIC CONCEPTIONS IN NEURO-PSYCHOLOGY

By the late Dr. JOSHUA ROSETT

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A KNOWLEDGE of the cause of angular motion has enabled the scientist to align under a common heading such widely different phenomena as the spiral form of the pine cone, the eddy in the water of the washbowl when the outlet is opened, the rotations and revolutions of the heavenly bodies, the form of the "twister" and perhaps the recurrence of social epochs. While the physical sciences have made great progress in the building up of such synthetic conceptions, the science of biology is lagging far behind, and this is especially true in the field of medicine. I shall attempt to show that such apparently widely different phenomena as the epileptic seizure, the onset and the awakening from sleep, the reaction of being startled, states of anxiety which merge into a number of the neuroses, the states of attention, of thought, of imagery and of hallucination, exhibit, upon analysis, not only a remarkable sameness of the elements of which they are constituted but a striking sameness of the pattern into which these elements are arranged as well.

In the same manner that the solution of a mathematical equation is made easier when reduced by the elimination of the common factors, so must an understanding of the manner in which the above-mentioned conditions differ from one another be enhanced by the mental abstraction of the features common to all of them.

An analysis of the physiological and psychological states enumerated discloses the fact that each of them begins with a period of disorientation of some degree in the present and proximate surroundings; that this period is followed by one of mental activity of one kind or another; that the latter is, in its turn, succeeded by more or less profound unconsciousness and by muscular activity, which merges into muscular relaxation; and that the cycle of each of these conditions is completed by a recurrence of the same events in the reverse order of succession of their onset. But though the order of the events is constant, we shall find that in a large number of instances the cycle is abbreviated, being short of its later stages and, in at least one instance, of the first stage. Whatever be the shortages, however, the student will have no difficulty in discovering the basic identity of the incomplete with the complete pattern.

Mention has been made of the fact that all the psychological and physiological conditions enumerated begin with a period of disorientation in the present and proximate surroundings. Before proceeding with our analysis we must pause for a brief definition of the latter terms.

In the first place the terms "present" and "proximate," as here employed, have reference to that part of the external and internal environment which is at the moment directly accessible to the sensory receptors. Standing by itself, however, such a definition is entirely inadequate from the point of view of a study in which the factor of *awareness* or *consciousness* is a prominent feature. For although it is true that the presence of a radio set is capable of producing a disturbance of the sensory receptors in a young baby, an idiot, a savage or a dog,

yet the disturbance is not informative to them of its particular significance, namely, that of the presence of an instrument for the conversion of certain electrical waves into sound. Such significance of a particular disturbance of the sensory organs is brought about by the memory of a great variety of past experiences with the particular object or condition.

To be disoriented in the present and proximate surroundings implies, therefore, a break at any point in the course of the sensory receptive apparatus by which it is disabled from conveying the disturbance of the sensory receptors to the associative apparatus of the cerebral cortex. The latter, being the "seat" of memories of past experiences, the result of an inability of the sensory receptive apparatus to convey to it different disturbances of the sensory receptors is that the specific significance of the present and proximate objects and conditions is lost, and the person or the animal is therefore practically severed from the immediate surroundings.

Since from the point of view of the present analysis the term "proximate" is applied to that part of the environment which is directly accessible to the sensory receptors, it must be distinguished from its synonym "nearby." A star is far away, yet since it can produce on the retina a direct impression which is capable of reviving memories of its significance, it is, from this point of view, proximate. On the other hand, microorganisms, of whose presence on the skin the person is unaware are, from the same point of view, "distant."

By the same token, the awareness of the presence of an object which is not at the moment productive of a perceived disturbance of the sensory receptors, implies orientation in the distant and the past—implies an act of memory of experiences with that object or condition at some time in the past—irrespective of whether that object is situated nearby or far away. Such awareness, which is independent of the activity of the sensory receptive apparatus is a purely mental act. Thus, a person may be aware of the presence of stars far away, or of microorganisms nearby, neither of which affects his sensory receptors at the time.

With these definitions in mind we may proceed with the analysis of the patterns of the several types of behavior in question.

The Epileptic Seizure

A number of different forms of this disorder are known to physicians, but no matter what the form, with the single exception to be pointed out later, they all begin with a period during which the person is more or less disoriented in his proximate surroundings.

A number of epileptic seizures set in with such rapidity that neither the subject nor the outsider can observe their development. In those instances in which the attack develops gradually, especially when the first stage is of considerable length, the subject remembers his experiences during that stage of its progress and is able to give an account of them afterwards. Soon after the person has become to a greater or less extent confused, or unconscious, of his proximate surroundings, distorted memories of certain past experiences, acquired directly or by representation, in a number of cases become active in the form of hallucinations. The degree of vividness of this distorted orientation in the past is in direct proportion to the degree of disorientation in the present. The reason for the latter will be pointed out later. When, for example, a person, during the onset of the seizure, has a vivid vision of a knight in armor on a fiery steed, who speaks in a thunder-voice, it is a certainty that he is at the time quite unconscious of his present and proximate surroundings. When the "vision," on the other hand, is hazy, orientation in the present is not entirely

extinct. In one of my cases the subject, a young woman, had one of her "minor" attacks as she was about to board a street car. The hallucination, which was the same in every recurrent seizure, was that of a balcony or veranda on which a number of well-dressed people were having tea. The "vision" was enveloped in a bright haze. While she was experiencing this hallucination, she was to some extent aware of the fact that the car conductor was urging her to board the car, and her feelings were those of uneasiness and embarrassment.

Following the stages of disorientation in the proximate surroundings and the mental activity of hallucination, the "major" epileptic becomes totally unconscious. The succeeding stages of the seizure are characterized by muscular rigidity and convulsions, and these are followed by a degree of muscular flaccidity which is in direct proportion to the degree of the preceding muscular activity.

After a variable period of unconsciousness, recovery takes place. The recovery of muscular function is manifested by a return of tonus, which may be detected by palpation and by different movements of the body and the limbs. A mild convulsion is not infrequent at this stage. Mental activity is next manifested by the occurrence of dreams, which are very common upon emergence from the major seizure. Orientation in the proximate surroundings is the last to return. In the process of taking rapid moving pictures of a number of such seizures, an arc light was placed near the patient. Upon awakening, a number of these patients gazed confusedly at the bright light and tried to reach out for it. They were dazed. When they were questioned, their answers were irrelevant in content, and the sentences were badly formed, with omissions and substitutions of wrong words.

This is the cycle of events of the complete, or major, epileptic seizure. The minor seizure is simply one in which the disability falls short of some of the last stages of the major seizure, rarely reaching the point of complete unconsciousness and still more rarely that of convulsions. The person is more or less disoriented for a variable length of time in his proximate surroundings, then recovers. Or the disability may proceed to the next stage of hallucination, at which point recovery may set in. In a number of other cases mental activity may be completely suspended for a few moments, and the person may quickly recover before having a convulsion, or after a very brief and localized muscular spasm. A patient who was under my observation for some years had had a number of minor seizures daily. The disability during each attack progressed to the stage of a momentary spasm of the muscles of mastication. The entire cycle of events occurred with great rapidity so that all that could be noted was the sound of the patient's teeth snapping together. He never fell, although he was somewhat dazed for a few minutes after each attack.

The several stages of the complete epileptic seizure are, therefore, the following: (1) disorientation in the present and proximate surroundings; (2) hallucinations, that is, a mental activity which consists in a vivid and distorted subjective reexperience of actual past experiences—a vivid and inaccurate orientation in the past and the distant; (3) complete unconsciousness; (4) muscular activity; (5) muscular flaccidity. These different stages are not, however, rigidly delimited but overlap on one another to a greater or less extent. Following the last, recovery takes place, in which the several stages enumerated recur in the reverse order.

There is one form of seizure which is short of the first stages—the so-called Jacksonian. The attack consists of a convulsive movement of a part or of a whole extremity, or of a part of the face.

Following the convulsive movement the muscles remain relaxed for a time. Throughout the attack the patient is quite oriented. When pointing out the reasons for the particular mode of succession of the several stages in the epileptic seizure, in the "startling" reaction, in the state of attention, of a thought, and the others, it will appear that the Jacksonian seizure is corroborative of the general argument held forth.

The Reaction of "Startling"

The condition for the production of this reaction is a sudden unexpected application of a stimulus, which need not necessarily be strong. The slamming of a door, a friendly slap on the shoulder from behind, a flash of lightning, the sight of a repugnant animal, the prick of a pin—almost any stimulus suddenly and unexpectedly applied causes the susceptible person or animal to bound into a state of more or less general muscular rigidity, in which the joints are immobilized by the equal contraction of the antagonistic muscles. Wild animals are "scared stiff" or "hypnotized" by the glare of a bright light at night and, becoming immobile, may be easily taken under these circumstances. It is for this reason that hunting at night by jack-light is prohibited in most of the states as being unsportsmanlike.

That much is familiar. A closer observation of this phenomenon reveals a number of interesting facts. It appears that the reason for the reaction is to be found in the fact that the nature of the stimulus not having been yet evaluated, the person or the animal can not react to it in an appropriate manner. Immediately the stimulus is evaluated, as when the person has had time to realize that the slap on the shoulder is by a friend, the general rigidity of the startle disappears. As the reaction consists in a fixation of the joints, we may legitimately surmise that it is a natural protective measure, which, by the establishment of a fixed base, prepares the organism for any possibly needed movement of the body and the limbs for purposes of aggression or escape.

Rapidly as the muscular rigidity sets in after the application of the unexpected stimulus, however, it is preceded by certain sensory occurrences. What happens immediately after the application of the stimulus is that consciousness is suddenly and intensely focused on it—narrowed—so that the person or the animal becomes to a corresponding extent disoriented in the rest of the surroundings; and so small may become the residuum of consciousness, that it is in a number of instances completely suspended. The reason for the complete extinction of consciousness when it is reduced below a certain scope, will be more conveniently pointed out under the heading of "The State of Attention." The extent to which consciousness is reduced in the "startle" is attested by the frequency of irrational behavior of the surprised or frightened person who, when asked later the reason for such behavior, offers the familiar reply, "I was so surprised I didn't know what I was doing." For one not to know what he is doing implies a considerable reduction of his conscious state.

The sensory disability in connection with the reaction in question may also be judged by many familiar instances of a remarkable degree of different anaesthesias. I have elsewhere cited my own experience of a temporary disappearance of a violent toothache upon hearing the cry of "fire" on a floor below. I recently saw a woman with a number of burns on her body and limbs, which she sustained in the attempt to stamp out a spreading grass fire near her house. So startled was she by the threatened danger that she felt not the least pain from the burns at the time. The explorer Livingstone is said to have felt no pain when his arm was chewed by a lion.

In instances in which the cycle of mental and muscular events which constitute the reaction in question is drawn out in point of time, vivid imagery and hallucination are not uncommon. The content of such imagery and hallucination depends, of course, on the particular mental composition of the subject. The familiar stories of lonely houses haunted by ghosts and devils have their source largely in such imagery and hallucination of persons who could not evaluate the nature of certain stimuli to which they were exposed, and who reacted to the slamming of doors, the rattling of windows and the howling of the wind in the chimneys by a drawnout "startle."

Following a brief but intense "startle," trembling, automatisms and other involuntary abnormal movements are not uncommon. Muscular exhaustion manifested by flaccidity, which is popularly known as a "let-down" terminates the ordinary attack.

States of Chronic Anxiety

Persons oppressed by anxiety, or fear, or afflicted with grief or tormented by suspense for a considerable length of time, exhibit the essential manifestations of continually recurring drawn-out "startling" reactions. The latter are, however, very much obscured by certain activities of the autonomic nervous system. These tend to aggravate the entire condition to a point where the original causative stimulus is frequently lost sight of, so that the only proof of its causality is a cessation of its action, when, unless permanent damage to the tissues of the body has been done, the abnormal state is rapidly dissipated. In the description of the symptoms of the reaction of "startling" I have omitted to mention the manifestation of the activity of the autonomic nervous system—pallor, flushing, sweating, goose-flesh, irregular heartbeat, the arrest of digestion and others—for the reason that the common "startle" is very brief, and whatever activity of the autonomic system is associated with it abates rapidly when the reaction is over. Under the continuous incidence of a stimulus to which the person can not react, however, the symptoms of activity of the autonomic nervous system in the long drawn-out and continually repeated reaction of "startling," constitute a source of chronic discomfort to the subject and a serious problem for the physician.

Through the obscuring haze of the symptoms of autonomic activity, it may be discerned that the subject is chronically somewhat disoriented in his surroundings, from which he is, consequently, to a certain extent severed. In popular language, "he lives within himself." This defective orientation in the present and proximate surroundings, not being sufficiently adequate to guide his memories of past experiences along channels of actuality, results in a kind of orientation in the past and the distant which, for the defect in the relations of the separate memories, is akin to dreaming or having hallucinations. The sudden stiffening of the muscles which characterizes the acute reaction of being startled has its equivalent in the state of anxiety in chronic muscular tensions alternating with periods of "let-down" or exhaustion.

The Onset of Sleep

The general resemblance of the onset of sleep to the epileptic seizure was noted many years ago by Dr. Gowers. A closer study of this condition reveals that the different steps, or stages, into which either of these states is divisible are the same, and that they follow each other in both conditions in the same sequence.

The first stage of the onset of normal sleep is a diminution of the activity of nervous apparatus which keeps the organisms "in touch" with the present and proximate surroundings—the sensory receptive apparatus. At a certain

point in the progress of this stage, while there is still a large residuum of orientation in the present and proximate surroundings, thought—that is, a correct orientation in the past and the distant—becomes active. With the further diminution of the activity of the sensory receptive apparatus, and the consequent diminution of the residuum of orientation in the present and proximate surroundings, memories (orientation in the past and the distant) cease to that extent to correspond to reality, and thought first merges into imagery and the latter into hallucination. This stage of sleep is followed by more or less profound unconsciousness.

Coincident with the onset of unconsciousness muscular activity takes place, manifested in a number of cases by the familiar jerking or startling movements. In a large number of instances these movements are sufficiently sudden and powerful to waken the sleeper. The next stage of sleep is characterized by continued unconsciousness and muscular relaxation.

In the process of awakening from normal sleep, the same as in the recovery from the epileptic seizure, the several stages of the onset are repeated in the reverse order. Muscular activity returns first, the person crouches, turns, stretches, yawns. Brief dreams are common in this stage. The person then becomes more or less rapidly oriented in the present and proximate surroundings.

Attention and Thought

Attention may be said to be the first stage of any one thought. Whether attention is on memories—on the past and the distant—or on the present and proximate, the appreciation of the significance of an object, or condition, or an element of memory attended to, involves a correlation of that item with memories of experiences with similar and dissimilar items. Although most of these facts are familiar, an example or two will serve to bring out their relevancy to the subject in hand. Observe the manner in which a textile merchant examines a piece of cloth in order to ascertain its quality. He looks at it and rubs it between his thumb and forefinger for a while, then stops, closes his eyes for a time, then opens them again, looks at the cloth and again rubs it between his fingers; and he repeats this action until he is satisfied of the quality. Even more familiar examples of such alternating actions may be observed in the tasting of a certain food or in the smelling of a certain perfume for the purpose of ascertaining, respectively, the taste and the fragrance. The exposure of the sensory receptors to the stimulus-object is alternated with an effort of comparing the present single impression with numerous memories of similar and dissimilar impressions in the past.

If, while the buyer is examining the cloth, one salesman will sing praises of its quality, another will tug the buyer by the sleeve, and a third will execute antics for his entertainment, the merchant will find himself unable to determine the quality of the cloth. He will say he can not "concentrate" his attention.

We must examine the significance of this "concentration" of the attention. We have noted that after gazing at the cloth for a while, the merchant closes his eyes. The same is true of the person who smells the perfume in order to ascertain its fragrance, except that the latter may close his eyes to start with, or if he keeps them open he gazes into infinity, that is, he is not looking at anything in particular. The fact is that in order to devote a certain degree of attention to any one object, condition, or thought, all the rest must be to that extent excluded from consciousness. And what is true of this relation of a whole object to all other objects, is likewise true of a part of an object to a whole. A minute attention to a drawer in a desk involves at the same time a corresponding degree of inatten-

tion not only to the rest of the furniture in the room but to the desk as a whole as well. In order to "think out" a problem relating to the stars, one must forget for the time being his other affairs. To the extent that the latter obtrude themselves upon the attention one can not think clearly about the stars.

In brief, a condition for a given degree of orientation within a small sphere is a corresponding degree of disorientation outside that sphere; and the smaller is the sphere attended to, the clearer is the orientation within that sphere and the wider is the scope of disorientation outside of it. In this respect the act of attention is analagous to the focusing of light. A light focused to a small bright point involves a corresponding absence of light outside of it.

Attention, however, refers to living organisms, the activity of whose functions is limited within certain bounds; a function which is either overactive or underactive beyond certain limits, ceases altogether. And this is likewise true of the state of attention, which may be progressively concentrated within a smaller and still smaller sphere down to a certain limit beyond which it ceases altogether. In other words, as the scope of disorientation increases in proportion as the sphere of attention is reduced, it is a fact that beyond certain limits the former spreads over the entire field, that is, the person becomes unconscious. Sustained attention on a small object or on a narrow line of memories is, as a matter of fact, conducive to sleep. The popular hypnotics, which consist in counting mentally a row of sheep, or of "reading one's self to sleep" are based on this fact. An objection might be discovered in instances in which the contemplation of a small object, such for example as the discovery of a certain abnormal cell under the microscope by a pathologist, will make him wide awake and alert. The fact of the matter is, however, that in this case the sphere of attention, far from being circumscribed within the narrow outlines of the cell, is very much expanded by the numerous memories revived by the picture under the microscope. Persistent gazing at the same cell by a person to whom it represents nothing more than a small circle or oval, would almost certainly result in his falling asleep.

The onset of sleep induced by a contraction of mental activities along a narrow channel is particularly favorable to imagery and vivid dreams. As the scope of orientation in the present and proximate surroundings is progressively diminished by limiting the activity of the sensory receptive apparatus, a distorted orientation in the past and the distant becomes correspondingly active. The content of the imagery and hallucination in such cases, too, depends, of course, on the mental composition of the subject. The ambitious tradesman may find his competitors in the poorhouse and himself on the golden throne of a merchant prince. The mystic may have revealed to him the heavenly light. History indeed records instances in which members of mystic fraternities have been regularly instructed into the means of inducing in themselves a state of being in which that light would reveal itself to them, as, for instance, by intent gazing at the navel for long periods of time at a stretch. The modern mystic gazes at an acorn or at the point of a needle. The professional hypnotist instructs his subject to gaze at the fingertip held before the eyes while assuming a mental attitude of entire obedience to commands.

A detailed discussion of the muscular activity connected with the state of attention and of thought, imagery and hallucination, would take us too far afield. It is sufficient to say that the postures and movements associated with the rapidly changing states of attention are to a certain extent characteristic of each such particular state, though largely

dependent upon the habits of the individual. When attention is on an external object, the sensory organs are moved in the direction of the object to be examined or the object is moved in the direction of the particular sensory organs. Once the most advantageous spatial relation between the object and the sensory organs is established, the joints are immobilized by the equal contraction of the antagonistic muscles and the posture thus established is maintained for the duration of that act. The final relaxation of the muscles signals the end of the particular state of attention. When attention is on a given line of thought, the sensory organs are as far as possible protected by appropriate movements and postures from the obtrusion of external stimuli, so that disorientation in the present and proximate surroundings, to a degree suited to the particular mental activity, may facilitate orientation in the past and the distant. A single hint regarding the temporal relation of muscular activity to thought must suffice. It is that planned *action* follows, does not precede, thought.

It appears, therefore, that, like the epileptic seizure, each state of attention, no matter how brief and fleeting, is initiated by a disorientation in the present and proximate surroundings, which is then followed by the mental activity of thought, imagery and hallucination—by an increasingly vivid and increasingly inaccurate orientation in the past and the distant. This stage is followed by more or less profound unconsciousness. The movements and the sustained postures are then resolved.

As in the case of the epileptic seizure, however, states of attention are seldom complete, usually falling short of one or more of the later stages. A person's attention may be for a second or less on a given object. The large amount of disorientation in the present and proximate surroundings which is coincident with the focusing of attention within a narrow sphere, initiates orientation in the past and distant—initiates thoughts relative to the object attended to. A further focusing of attention, implying as it does an increase in the scope of disorientation in the present and proximate, results in an overlapping of thought on imagery. At this point the process is usually arrested and the person returns to his former state; the postures associated with the particular state of attention are undone, the functional scope of the sensory receptive apparatus is widened, and the person ready for another state of attention.

Vividness Versus Accuracy

Thought, imagery and hallucination, in the order mentioned, are increasingly vivid and increasingly inaccurate subjective reproductions of actual past experiences. This increase in vividness, which goes hand in hand with an increasing inaccuracy, is corroborative of the present thesis and will be more conveniently explained in the following discussion of the anatomical and physiological substratum of the phenomena described in the foregoing.

Underlying Causes

In the same manner that we trace the cause of the spiral form of the pine cone, of the rotations and revolutions of the heavenly bodies, of the eddy in the water and the whirlwind in the air to a collision of forces of different direction, with the resultant of an angular line of motion, so we can trace the reason for the same basic form of the different neuro-muscular conditions described in the foregoing to a single factor which is operative in all of them. Granting that we are in advance of that stage of civilization when thought, imagery and hallucination were taken to be due to a pervasion of the organism not merely by an unknown but by an unknowable force, we may be permitted to cast a cursory glance at that factor.

(1) The first stage of the different modes of behavior described above is a greater or less degree of disorientation in the present and proximate surroundings. Since it is the sensory receptive nerve apparatus which keeps the person or the animal "in touch" with these surroundings, we must conclude that the disorientation in question is due to some kind of disability of that apparatus.

(2) The second stage in each of the conditions described is the mental activity of thought, which may merge into that of imagery and the latter into hallucination. As has been stated, these mental functions are increasingly vivid and increasingly inaccurate subjective re-experiences of past actual experiences. This progressive increase in vividness and inaccuracy is in direct proportion to the extent to which sensory reception has been reduced. Since in the normal direction of nerve conduction the associative apparatus of the cerebral cortex—"the seat" of memories—is situated anatomically in advance of the sensory receptive apparatus, we must conclude on the basis of the clinical facts mentioned (a) that a diminution of the function of the latter nerve apparatus initiates the activity of the nerves of the association system; and (b) that an increasing diminution of the function of the sensory receptive apparatus results in a disorganization of the activity of the associative apparatus in which the separate items gain at the same time in vividness. The cause of the disorganization of memories—of the disruption of their mutual relations—is easily accounted for, on the basis of a large number of clinical facts, by their lack of guidance on the part of the nerve apparatus which keeps the person "in touch" with actual existences—the sensory receptive apparatus. The cause of the increase in the vividness of the disorganized memories lies, as will be presently seen, in that very fact—the defective functioning of the associative apparatus.

In anatomical relation with both, the sensory receptive apparatus and the associative apparatus, is the large nervous plexus of the thalamus and hypothalamus. All clinical and experimental evidence is to the effect that the thalamic plexus is the highest center of the basic vegetative autonomic functions of the body and, by virtue of that, of the emotions. This highest center of the emotions is largely under control of the associative apparatus of the cerebral cortex. Injuries to the latter, or injuries which sever its nerve connections with the thalamic plexus, by permitting a wider activity of the latter, result in an exaggerated intensity and vividness of the emotional coloring of experienced sensations.

The same functional defect of the associative apparatus in the later part of the second stage of the conditions in question, which is the cause of the disorganization of memories, results in its defective control of the functions of the thalamic plexus, with the consequence of an exaggeration of the emotional factors of intensity and vividness of the separate memories.

We have seen that a condition for the activity of thought is a reduction in the functioning of the sensory receptive apparatus to a point at which memories are guided by a large residuum of sensory reception along channels of actual existences, without permitting the latter to obtrude themselves unduly on the mental activity. Under such circumstances the associative apparatus still controls the display of thalamic function to a large extent, so that memories of past experiences are only slightly tinged by emotional coloring. Thought, therefore, in contradistinction to imagery and hallucination, although accurate with respect to relations of actual existences, is vague with respect to the colors, outlines, etc., of the existences themselves.

(3) The third stage in the conditions named is more or less profound uncon-

sciousness, testifying to a large reduction or suspension of the function of the associative as well as of the receptive nerve apparatus.

(4) With the reduction or the suspension of the function of associative apparatus, the function of nerve systems which are anatomically and physiologically situated in advance of them—the motor nerve systems—are activated. This is manifested by the postures and movements characteristic of each of the conditions described.

(5) The fifth stage is characterized in all of the conditions described by muscular relaxation. This testifies to a disability of the last link of the reflex arc, that which proceeds to the muscles.

Summary

We thus see that the cause of the particular events, and their particular mode of succession, in the several conditions described in the fore-going, is a wave of disability, or inhibition of function, which floods in succession the several links of the reflex arc in the normal direction of nerve conduction, from the receptive, through the associative and to its muscular end. As the function of each of these links of the nerve pathway is reduced or extinguished, that of the next succeeding link is activated to a corresponding degree. After involving the muscular end of the reflex arc, the wave disability recedes, and it may be observed in a number of cases that recovery of function proceeds in a direction from the muscular to the receptive end of the nerve pathway. In the greater number of instances, however, the disability does not involve the entire reflex nerve pathway but after proceeding for a variable distance along it, recedes. The particular condition is in such instances short of one or more of the later stages. Such is notably the case in the instances of thought, of the "startle," and of the minor epileptic seizure.

We have seen that in the instance of Jacksonian seizures, the person remains conscious and oriented. The disorder consists of a localized convulsion and subsequent relative flaccidity of the muscles involved. The occurrence of these seizures is corroborative of the present thesis. The cause of the disorder is a small tumor, a scar or other lesion in the immediate neighborhood of the motor area of the cerebral cortex. The wave of disability in these cases floods the nerve pathway from the motor area onward, leaving the nerve systems in the rear of it—the associative and receptive apparatus—intact. The person, therefore, remains conscious and oriented.

Concluding Remarks

Scientific eras, like political and economic eras, overlap, so that it is difficult to determine where one ends and the other begins. In the medical sciences of to-day, traces of medieval superstition may be discerned in the lingering tendency to view the more proximate causes of the mental functions with a degree of awe which forbids any other attitude toward them than one of adamant agnosticism.

This agnosticism must be largely dispelled upon finding that the apparently intangible mental functions can be aligned with others of a tangible nature. Upon analysis of a unit of thought we found that no matter how brief and subtle it may be, and how different it is in appearance from such a gross and cataclysmic occurrence as the major epileptic fit, it is essentially very much like the latter; both phenomena being constituted of the same events arranged in the same order. *The differences between them are mainly two: one, of magnitude; the other, of relevancy with respect to our well-being.*

LAND UTILIZATION IN COSTA RICA

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Costa Rica, one of the smaller and least mountainous of the Central American republics, presents remarkable contrasts in relief, climate, vegetation, soils and land utilization within a short distance from the coast toward the interior. These differences are due primarily to the physiographic contrasts to be found in the area and to the resultant climatic provinces.

A traveler on the Northern Railway of Costa Rica will traverse most of the zones on the short trip from the coast at Limon to the capital at San Jose. In a distance of 103 miles the train traverses first the Atlantic coastal plain, then the foothills by means of a steep climb through the canyon of the Rio Reventazon, then the highlands, crossing the Continental Divide (elevation 5,137 feet, or 1,566 meters), and finally descends upon the Costa Rican Meseta, an intermontane plateau, to the city of San Jose at an elevation of 3,800 feet. In few places in the world can so many contrasted zones be traversed in so short a distance.

Physiographic Regions

Physiographically the section of Costa Rica covered in this paper (Fig. 1) may be divided into three distinct provinces: (1) the Caribbean plain, (2) the foothills and volcanic mountain section of the middle cordillera, and (3) the Meseta or intermontane plateau. The coastal

FIG. 1. MAP SHOWING ALTITUDE VARIANCE IN NORTHEASTERN COSTA RICA

plain, composed of slightly consolidated sedimentary rocks of Tertiary or Quaternary age, is flat and largely featureless. This plain is one of the most important provinces as it occupies nearly one third of the country. The northern part of the plain, which extends from the Nicaraguan boundary to south of the port of Limon, is extremely flat, being broken only by small hills, none of which are more than 1,100 feet above sea level. The central cordillera is divided by the canyons of the Rio Grande in the north and the Rio Reventazon about the middle of the country. The railroad uses the middle canyon of the Rio Reventazon to climb out of the coastal plain and cross the mountain range to the plateau. This central range or "Volcanic Range" consists of a number of volcanic peaks that increase progressively in height from Orosi (5,154 feet) in the northwest to Turrialba (10,995) and Irazu (11,325 feet) in the southeast in the vicinity of the Reventazon canyon (Fig. 1). This range is somewhat curved so that the summit-line describes a broad arc with the concave side facing the Caribbean. The Central Plateau, or Meseta, is covered by thick deposits of volcanic ash that provide excellent soils for the densely populated coffee country.

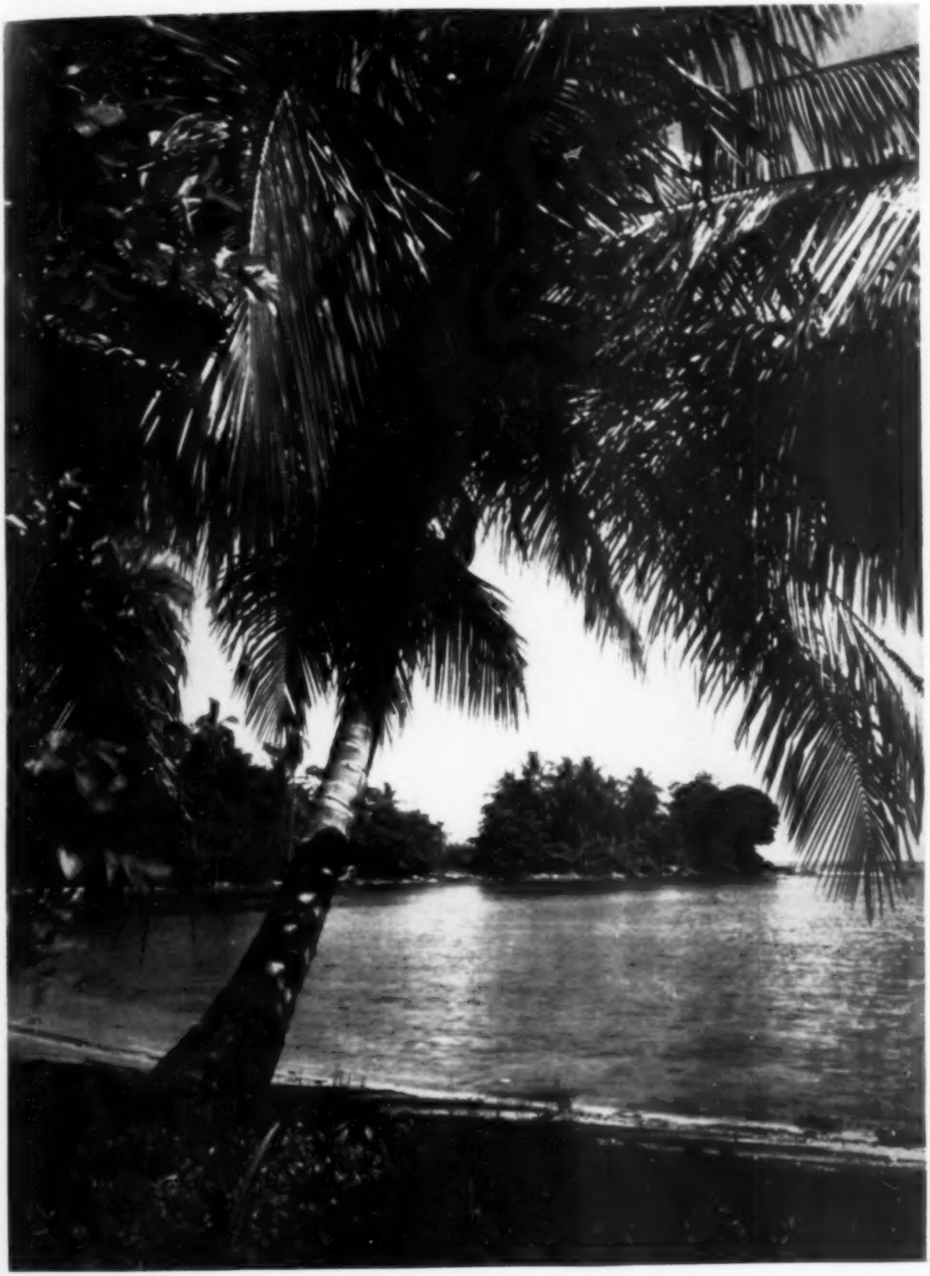
Climate and Natural Vegetation

Although climatological data for all Central American countries are extremely meager, the climatic zones are well enough marked by contrasts in natural vegetation and land use to make possible the recognition of three distinct climatic types. The Caribbean plain with its heavy rainfall, high humidity and constantly high temperatures lies in the tropical rain forest region, a true "tierra caliente." This climatic zone, ideal banana and cacao country, extends up the slopes of the volcanic range to an altitude of about 2,000 feet. Above that point the tropical high altitude or plateau climate begins. The entire white and Indian population of Costa Rica lives in this "tierra templada" region. On the upper slopes of the volcanic peaks a third climatic type, the "tierra fria," appears, but this zone is as yet unoccupied.

The natural vegetation responses to these climatic zones are quite definite. The Caribbean lowlands and lower slopes of the volcanic range are covered by the true selva. In the uncleared forests, and there are many of them in spite of the extensive banana and cacao plantations, tropical hardwoods dominate. This forest contains a wealth of species, many of which are valuable for furniture and cabinet woods. The most important trees are the Spanish cedar and the ceiba. The relative scarcity of mahogany in the Costa Rican rain forest is more than offset by the great abundance of Spanish cedar and other important cabinet woods. Forest resources of the area will continue to support an important and growing lumber industry. Associated with the large hardwood trees are vines, lianas and many parasitic plants, including the orchid. On the higher slopes of the "tierra templada" open forests of pine, oak and other species of the temperate regions appear. On the Meseta and in the smaller intermontane valleys, forests give way to grassland savannas. However, most of these areas have been under cultivation for so many years it becomes difficult to determine the original vegetation. The summits of the volcanoes are barren of vegetation.

Colonization and Settlement

Like the other Central American republics, Costa Rica was settled from the west coast, since the dense jungle along the Caribbean coastal plain made it almost impossible to reach the plateau



COCONUT PALMS FRINGE THE BAY AT LIMON

from that side. The first attempts at settlement by the Spaniards were at a point on the Pacific coast near the present site of Puntarenas. This settlement, made in 1524, was abandoned two years later, and from that date until 1560, no further attempts were made. However, in this interim the Spanish conquistadores did try to establish settlements on the Caribbean coast. Near the mouth of the Rio Sixaola, on the present Panamanian border, a settlement was made in 1540, and three years later a second one was established on the lower Rio Reventazon. From that point the Spaniards attempted to go inland to the plateau along the Reventazon Valley, but the party was overwhelmed by the wild forest Indians of the jungle area. These two Caribbean coastal settlements were then abandoned (1544) and no further attempts to occupy this coast were made until near the close of the nineteenth century, more than three hundred years later.

In 1560 two expeditions were sent out from the *Audiencia* of Guatemala to each coast of Costa Rica. The one to the Caribbean coast failed to reach its destination, but the other established a base on the Pacific coast and moved up the steep western slope of the mountains to the Meseta Central. The Meseta Central is divided into a western (Occidental) and an eastern (Oriental) division (Fig. 1), by a low water parting at the Continental Divide. The expedition crossed over the Divide and made the first permanent white settlement in Costa Rica at Cartago (1563) in the Meseta Central Oriental near the headwaters of the Rio Reventazon. The colony flourished, but due to its extreme isolation from other Spanish settlements of the time, its growth was slow. The Indians of the plateau country were never numerous. An estimate during the early part of the sixteenth century placed their number at about 27,000. They were rapidly absorbed by the whites or were deported to Panama or Peru so that to-day the republic contains fewer than 4,000 pure Indians. With the lack of Indian labor in the plateau country and the extreme isolation of the first settlement, the Spaniard of the Meseta, in contrast to the Spaniard in Mexico or Peru, had to do manual labor and become self-supporting. The early settlers of Cartago included Spanish women, quite in contrast to most early settlements, and this insured a dominantly white population from the beginning. In spite of its name, no fabulous riches were found in Costa Rica, hence Spain seemingly forgot or at least ignored this small colony, placed high in the mountains on the eastern slope of the Continental Divide. For more than a century no further white settlements were made in Costa Rica, although several parishes, based on Indian villages, were established on the Pacific slope. Further attempts to establish contacts with the Caribbean coast by way of the Rio Reventazon Valley failed because of the impenetrable jungle and the wildness of the Indians. Thus the Spaniards in Cartago had to content themselves with remote contacts with Spain via the west coast and Panama, and turn their backs on the east coast. It is interesting to note that Cartago is only eighty-six miles by rail from the Caribbean port of Limon, yet that distance was never bridged by white man until toward the close of the nineteenth century. The building of the railroad (1871–1890) connected Cartago (1563), the oldest white settlement in Costa Rica, with Limon (1880), one of the most recently established cities of the republic. For more than a century after the founding of Cartago no further settlements were made by Spain, but in the early part of the eighteenth century active colonization began to radiate from Cartago. Having turned their backs on the Caribbean coastal region, the next

RAILWAY BRIDGE IN THE HIGHLANDS[1]

colonists recrossed the Continental Divide and established themselves on the drier and more fertile Meseta Central Occidental. Not only was the land of this area better suited to agriculture and habitation, but it was nearer the mother country by the Pacific coast route. It seems strange that it took the Spaniards nearly 150 years to realize this, but one wonders whether during that time they were not hoping to establish contacts with the Atlantic coast. New settlements were made at Heredia (1706), San Jose (1736) and Alajuela (1790). By 1835 the population figures of districts dominated by these four settlements were as follows:

San Jose	23,606
Cartago	19,700
Heredia	15,262
Alajuela	8,930

In the early part of the nineteenth century Costa Rica separated from Spain and established a republic. The capital was moved from Cartago to the larger and better located city of San Jose. The history of the republic from the time of its independence to the latter part of the nineteenth century is one of many revolutions. Several attempts at unifying the Central American states into one nation failed. After the William Walker incident, Costa Rica, with its highest percentage of white population, emerged as a well-organized republic. The dream of the founders of Cartago three centuries earlier to connect the plateau with the Caribbean coast was still cherished, and in the early 1870's work was begun on the railroad down the Reventazon Valley to the coast. The increase in population on the plateau had caused the whites to spill out of this high basin and flow down the Reventazon Valley as far as Turrialba.

The Building of the Railroad

In 1871, Don Tomas Guardia, dictator of Costa Rica, determined to build the

[1] Photographs obtained through the courtesy of the Pan American Union.

TURRIALBA VOLCANO

railroad to the Caribbean coast. He invited Henry Meiggs, builder of several railroads on the west coast of South America, to undertake the task. Meiggs gave the contract to his nephew, Henry M. Keith, who immediately sent for his younger brother, Minor C. Keith. Arriving on the Pacific coast in 1871, the Keiths proceeded by mule to San Jose, and then on down the east slope of the mountains to the Caribbean coast. The journey from San Jose to the coast required seven days of untold hardships. At that time the Costa Ricans had a saying that "the first time a man made a trip over this trail he was a hero, but if he did it a second time he was a damned fool." Minor Keith made many trips over the trail, and in the course of twenty years built the railroad to the coast.

In 1871 there were no ports on the Caribbean coast. The site of Limon was a flat, swampy area with an extremely unhealthful climate. It offered no good harbor, but being possibly the best place along the coast for the tidewater terminus of the railroad, it was selected as the starting point. The Indians of the region would not work, and the whites and Indians of the plateau could not be persuaded to go to the unhealthful lowlands, hence all labor as well as most of the supplies for the new railroad had to be imported. Keith secured the first shipload of laborers from New Orleans. Of more than two thousand white men brought in at that time, few survived. Jamaica Negroes, the next laborers imported, proved to be capable workers in the tropical rain forest. About that time the French began work on the Panama Canal and offered higher wages for labor. Most of the Jamaica Negroes deserted and went to Panama. Keith then contracted for two thousand Italian laborers, but these were unsuccessful, and after a time the surviving ones chartered a ship and returned to Italy. By that time the French enterprise in Panama had failed and the Jamaica negroes returned to Costa Rica. This insured sufficient labor to complete the railroad. In addition to labor troubles, Keith had many financial difficulties. His own credit and that of the Costa Rican government were endangered numerous times, but the Costa Rican people came to his rescue at the critical times, and in the end he paid back their money and gave them the railroad to the plateau.

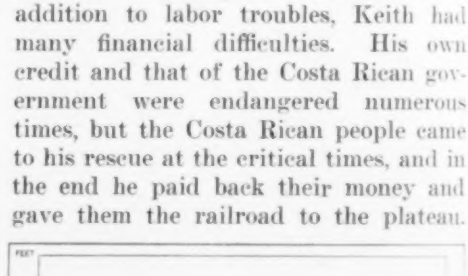


FIG. 2. PROFILE ALONG THE RAILROAD

Once during the construction period operations were suspended for nearly three years while Keith spent that time in England trying to raise more money to complete the line.

The original plan for the road led westward from Limon along the north flank of Turrialba Volcano to Rio Honduras Valley and thence over the pass to San Jose. The line was completed to Rio Sucio, about seventy miles from Limon, by 1882. Keith had to finance the operations out of his own funds. During that period, when further construction was stopped, banana plantations were begun, to provide the partly completed railroad with a commodity for export. Being unable to tap the coffee country on the Meseta, Keith created traffic by planting bananas extensively in the Matina and Zent Valleys near the coast, and on the Santa Clara Valley on the north flank of Mount Turrialba (Fig. 1). This was the beginning of the great banana industry of Central America. Shipments were soon made by steamers to New Orleans and to New York. By the time construction was again started on the main line to the plateau, a new route had been selected. The old plan to go around the north side of Mount Turrialba and through the pass to San Jose was abandoned in favor of the southern route up the Reventazon Valley through Cartago and over the Divide to San Jose. This new route branched off from the original line west of Siquirres and immediately began the ascent of the Reventazon Canyon. The old line from Siquirres, although now only a branch, has continued to be one of the best revenue sections of the entire system because it serves the fertile Santa Clara Valley. The chart (Fig. 2) shows the profile of the main line of the railroad from the coast at Limon to San Jose. From Limon to La Junta, at the entrance of the Reventazon Valley, the grade is gentle, La Junta, 39 miles from Limon, being only 187 feet above sea level. In the next 24 miles to Turrialba the road climbs steadily to an altitude of 2,037 feet above sea level. From Turrialba through Cartago to the summit of the Continental Divide (5,137 feet above sea level), the climb is 3,100 feet in about thirty miles, with steep grades and sharp curves. This section of the road, the most expensive to build

A SLEEPY MOUNTAIN VILLAGE ON THE HIGHWAY

TRANSPORTING BANANAS TO THE RAILROAD

and operate, is the most scenic part of the route. From the Continental Divide the road drops to San Jose at an altitude of 3,800 feet. In 1890 the railroad was completed and the first trains were run from San Jose and Cartago to the Caribbean coast. Cartago was connected at last with the Atlantic Coast, New York and Europe, 327 years after it was established. This ushered in a new era for Costa Rica, as it removed the plateau settlements from extreme isolation to one of easy contact with the outside world. The railroad provided not only passenger service to and from the plateau, but also an easy outlet for coffee and other products of the plateau, as well as for the bananas and cacao of the Caribbean lowland. Later a similar although shorter line was built westward from San Jose to the Pacific port of Puntarenas. With the completion of this line, Costa Rica had one of the three transisthmian railways of Central America. The road to the Pacific coast has not produced the revenue of the Caribbean line because of direction and because of the lack of commodities to be shipped from the Pacific coastal lowlands.

Land Occupance and Land Utilization

From the point of view of land occupance and land utilization, three zones may be recognized. (1) The Caribbean coastal plain, dominated by forests, but containing the large banana plantations and the extensive production of cacao, as well as a growing timber industry. (2) The Meseta Central, open country with few trees, either in grazing activities, or, if in crops, dominated by coffee, with numerous subsistence crops. (3) An intermediate zone, not too well defined, that combines some of the qualities of each of the other two zones. This intermediate area is found along the Reventazon Valley, with the lower slopes producing some bananas and cacao. On the higher slopes, coffee becomes important, with banana palms used only to shade the coffee trees and not grown for their fruit. This area is truly a transitional zone.

The Caribbean coastal plain was the

land of the tropical rain forest and the forest Indian until after the beginning of the construction of the railroad. The railroad company, as has been shown, needing some commodity to transport, established banana plantations along its right-of-way and initiated the development of the great banana industry. While this area is still an important producer of bananas, it has declined because of soil depletion and competition with more recently cleared areas. Cacao, grown in this area for a long time, did not become important until after the decline of the banana industry. Since cacao trees require substantially the same climate as the banana, they can be planted in lands where the banana was formerly important. The area is an agreeable habitat for the Jamaica Negro, who came into these lowlands to build the railroad and remained to grow bananas and cacao. The Negro problem is becoming one of increasing proportions since they are advancing farther up the railroad toward the plateau. At present the color line between the native whites and Indians of the plateau, and the imported Jamaica Negroes of the lowlands is reached at about 2,000 feet in the town of Turrialba. Below this town more than 90 per cent. of the population is Negro; above, over 90 per cent. is white or Indian. This introduction of great numbers of Negroes into one of the few predominantly white countries of the tropics has been called by one writer an "ethnological crime similar to that committed by the old European slave traders." The fruit company introduced thousands of Negroes into the area and failed to repatriate them. One wonders, however, who would cultivate the bananas and cacao if the Negroes were deported.

The Meseta Central presents a picture entirely different from that of the Caribbean lowlands. Settled by the Spaniards in the sixteenth, seventeenth and eighteenth centuries, the population is dominantly white. Since the Indians of the plateau were never numerous and made poor agricultural workers, the white settlers had to do their own work on the farms. Extreme isolation and retarded immigration caused the land holdings to be broken into small farms. Coffee is by far the most important crop, and has been for a long time. The Costa Rican Meseta is one of two important coffee-producing areas in Central America, the other one being in the highlands of Guatemala. For a long time the coffee of this region moved to the European market, since Americans, being accustomed to cheaper grades, would not pay the price for high quality coffee. Increasingly larger quantities of "mountain grown coffee" are finding their way into the United States and are creating a demand for higher quality coffee. In addition to the many coffee "fincas" or estates, subsistence crops such as corn and beans are grown, and an important grazing industry has developed. Near the cities dairies have become well established. These are usually quite modern, though milk is still delivered in San Jose in cans fastened onto the back of a burro. The plateau area combines the modern and the primitive in a pleasing way, particularly as regards transportation. In San Jose one may see the modern railroad, street car and automobile, and alongside these the cumbersome, solid-wheel coffee carts drawn by a team of oxen.

Land use in the intermediate zone is less distinct than in the two zones already considered. As one reaches the upper limit of the wet tropics at about 2,000 feet elevation, banana plantations, cacao plantations and the ubiquitous Negro drop out of the picture, to be replaced gradually by coffee fincas, cattle ranches and white people. The complexion of the population changes abruptly near Turrialba, and throughout

NATIONAL THEATER SEEN THROUGH ARCADE OF HOTEL COSTA RICA

the intermediate zone as well as on the Meseta the population is dominantly white, with some Indian and some Mestizo strains. In this area, near the town of Turrialba is grown the delicious sugarloaf pineapple that is served to passengers as the train stops at the station, but for some reason the fruit is not exported. Some day Costa Rica may recognize the value of this high quality fruit, which is far superior to Hawaiian pineapple, and will market it in the United States. This zone represents the lower limit of white settlement from the plateau and the upper limit of Jamaica Negro occupancy from the wet tropical lowland. One wonders if the white Spanish population of Costa Rica, being transitional in character, will be able to hold its own in the area, or be displaced and forced to retreat to the plateau by the advance of the Negro.

Cities—Contrasts in Urban Development

The towns and cities of the three zones show marked contrasts in development and reflect the environment of each zone as truly as the rural landscape. The towns and villages along the railroad may be grouped as follows: (1) Caribbean lowland towns, Limon and Siquirres, (2) intermediate zone, Turrialba, and (3) plateau cities, Cartago and San Jose (Fig. 1). Only one town in each region will be considered.

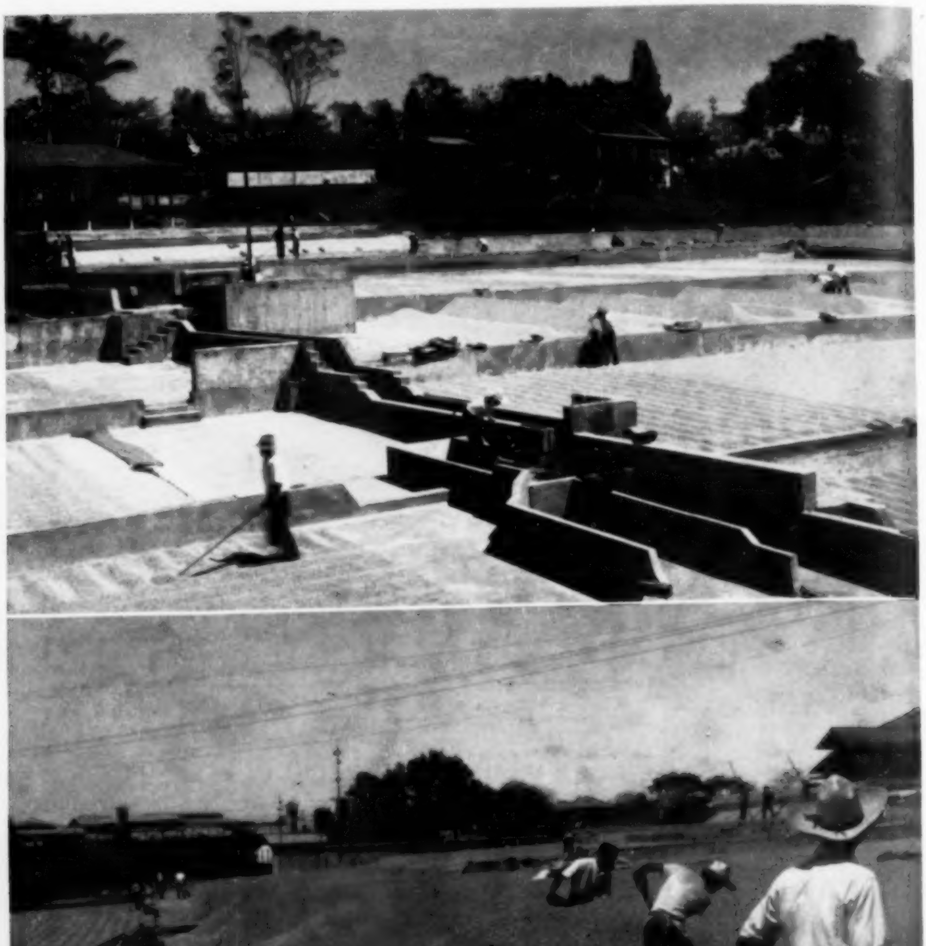
Limon is truly a city of the rainy tropics, but because of money spent by the railroad and the fruit company it has good sanitation and paved streets. Along the sidewalks are colonnades to protect one from the sun and heavy rains, and most of the houses have a second story with balcony extending over the sidewalk. Large open doors and windows allow a maximum of air to circulate. Buildings are of wood or stucco, but are usually covered with a corrugated iron roof of sufficient pitch to turn the heavy rains. Everything considered, they show a definite response to heavy rains, high humidity and bright

A VIEW OF CENTRAL MARKET IN SAN JOSE

sunshine when it is not raining. The docks, modern steel and concrete structures built by the fruit company, can accommodate several boats at the same time. The main dock is equipped with modern banana-loading machinery. A point of interest is Vargas Park, a small botanical garden in the heart of the town. Since the population of Limon is more than 90 per cent. Negro, it is not in any respect a Costa Rican town, but resembles most coastal cities of the Caribbean.

Turrialba, the only town of the intermediate zone, is smaller than Limon. Its population is greatly mixed, since it is near the color line. Settled originally from the plateau, the still dominant white population is being gradually crowded out by the ever increasing Negro. The houses are dominantly of wood and are one-story. The roofs, usually of corrugated iron, are less steep than those of Limon. The native population that meets all trains, offering pineapple and other foodstuffs for sale—or begging for money—are a mixed lot, showing the cosmopolitan nature of the population. Turrialba is primarily a way station on the railroad, but it is also a fairly thriving agricultural center.

San Jose, in the Meseta Central Occidental, presents a marked contrast to either of the above-mentioned places. Although considerably younger than the original settlement of Cartago, it has profited from being the capital of the country for the last century and has received more benefits than other cities. Although located in the earthquake belt and damaged several times by severe tremors, the city has never suffered the complete destruction that visited Cartago in 1910. San Jose is well planned with wide, paved streets, and is dominated by substantial one- and two-story stone buildings. Although "tin" roofs are increasing in number, the tile roof is still important. With less rainfall than in the other cities, flat roofs are in evidence. San Jose has numerous government and public buildings that would do justice to a city many times its size. All in all it is a true capital city of the plateau



CLEANING AND DRYING COFFEE IN THE HIGHLANDS

country, and on a small scale resembles Mexico City or Havana.

The Resort Industry

Costa Rica is making every effort to attract tourists. The excellent weekly steamship service of several lines calling at the ports of Limon and Puntarenas and the regular service of Pan-American Airways are giving the country contacts with the United States and other parts of the outside world. The railroad to the plateau from either coast provides the tourist a scenic trip to the capital city and other points of interest on the plateau. In addition Costa Rica is beginning to build good highways into the mountain country. The government has not been slow in recognizing the advantages gained from tourist trade, and by means of the National Tourist Board of Costa Rica is making every effort to acquaint the world with the country. Truly this republic is shaking off the bonds of isolation that it endured for more than three centuries after the founding of Cartago.

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BOTANICAL GARDENS AND MAN

"Man was lost and found in a garden!" In a garden may be found both rest and refreshment to soul and body and also inspiration with opportunities for reflection and research.

This applies to the humblest plot as well as to the botanic garden, and much may be learnt from a careful study of the development of the commonest weed. In the botanic garden where "Every tree that is pleasant to the sight and good for food" may be grown, as well as those of service to mankind, as the source of drugs, spices, beverages, fibres, timbers and such like, the educational possibilities and openings for research are far greater.

The search for plants yielding drugs and spices led to the foundation of botanic gardens; for in the monastic gardens of the Middle Ages—the forerunners of the botanic gardens attached to the universities—the cultivation of "simples" was one of the chief concerns of the community. Interesting survivals of these early physic gardens may still be seen in the Botanic Garden at Padua, and the Apothecaries' Garden at Chelsea—the Chelsea Physic Garden.

The search for spices has caused men to travel far and wide over the surface of the earth, has destroyed monopolies in the trade in economic products derived from plants (cloves, nutmegs, cinnamon, etc.), and has led to the establishment of gardens for their cultivation and exploitation. In this way many of the tropical botanic gardens have come into being, and through their efforts new markets have been opened for the drugs, spices and other economic products, native to one particular locality and under the control of one nation.

Botanic gardens, wherever they may be situated, should be the Mecca to which we turn for correct identifications of plants of economic value. They should also be a source of supply, both of economic and decorative plants, to other gardens or countries for the general good of mankind. Would that in these anxious days we could find and distribute that tree "whose leaves were for the healing of the Nations!"—*Arthur W. Hill (Director, Royal Botanic Gardens), Journal of the New York Botanical Garden, August, 1941.*

BONDING THROUGH HYDROGEN

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ONE of the most remarkable achievements of man's mind is the proof that all material things known to him are in the last analysis composed of a surprisingly few distinct elementary particles. No less an achievement has been the knowledge man has gained of the nature of the bonds which tie these few particles into the myriads of combinations which form the world he sees.

These bonds may be divided into three classes: those which bind the elementary particles into the nuclei of atoms, those much weaker ones which tie atoms together to form molecules, and the still weaker ones acting between molecules and between different parts of the same molecules. The first of these, the nuclear bonds, require such great forces to disrupt them that only in recent years has it been possible to do so. Considerable attention is now being focused on them. The second of these, the electrovalent and covalent bonds between atoms, can be made and broken with such forces as heat and electric potential available in the ordinary laboratory. A great amount of study has been given to them, and much has been learned about their nature. Because of the relatively small energy involved in the third class of bonds there is a tendency to underrate their part in determining the structure and properties of matter. The physical and chemical changes which require so little energy that they take place freely under ordinary conditions of temperature, pressure, etc., are among those which are of greatest significance to man. One of the most important types of these weak bonds comes about through the sharing of the positive charge, or proton, of a hydrogen atom between two atoms, X and Y, either of the same molecule or of different molecules, to form a bond between X and Y. Such a linkage is usually termed a hydrogen bond or a hydrogen bridge. Because of the abundance of hydrogen and of the atoms found to participate in hydrogen bonding—carbon, nitrogen, oxygen, fluorine, chlorine and sulfur—these bonds occur in many different phases of science. Their prevalence, however, has only recently begun to be realized.

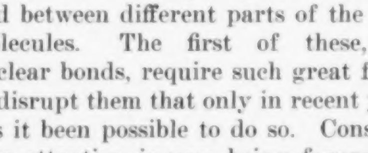

FIG. 1

Association between like and unlike molecules produces abnormalities in many physical properties of compounds—boiling points, freezing points, viscosities, dielectric constants, vapor pressures, solubilities, heats of mixing, of fusion and vaporization, etc. As data accumulate it becomes increasingly obvious that the most frequent cause of association is the hydrogen bond. Water, if it were not associated through hydrogen bonds, would be a gas at ordinary temperatures.

and hence life as we know it would be impossible. Furthermore the function which this substance has in both plant and animal life is very largely dependent upon its ability to donate as well as to accept protons in the formation of hydrogen bonds. In addition, alcohols, phenols, oximes, amides, amino acids, certain of the amines and other organic compounds have long been known to be associated because abnormalities were found in their physical properties. From recent measurements of infrared absorption spectra this association has been shown to be of the hydrogen bond type. Furthermore, other large classes of compounds which do not have a proton held loosely enough to be shared in hydrogen bridges—nitriles, nitro compounds, esters, aldehydes, ketones, ethers and certain amines—have been found to form complexes with other atoms by accepting a proton in hydrogen bond linkage. The importance of the latter classes of solvents to industrial chemistry is well known, and their use as solvents is in many instances dependent upon their ability to form complexes with the solute through hydrogen bonds.

The phenomenon of chelation, or the formation of rings within molecules, of wide occurrence in organic chemistry, affects the physical properties as well as the chemical reactivities of the compounds in which the chelated rings are formed. Hydrogen bonding is often the cause of chelation, as in o-nitrophenol, salicylaldehyde, methyl salicylate, o-hydroxyacetophenone and the enol form of acetylacetone.

Proteins, tissue builders in the body, are now believed to be held in their native configurations by hydrogen bonds. X-ray diffraction work[1] gives evidence that protein molecules are composed of elongated backbone structures, somewhat as shown below (Fig. 1):

[1] See, for example, Astbury, "Fundamentals of Fibre Structure," Oxford University Press, 1933.

In these structures it is probably hydrogen bonding between the NH and C = O of the adjacent chains which ties the chains together. The arrangement of the chains as shown by the x-ray work indicates this but does not definitely prove it since the x-ray patterns fail to reveal the position of the small hydrogen atoms. Infrared absorption spectra show that the NH group in simpler compounds like pyrrole will share its proton in hydrogen bonding and that the carbonyl group in simple compounds like acetone

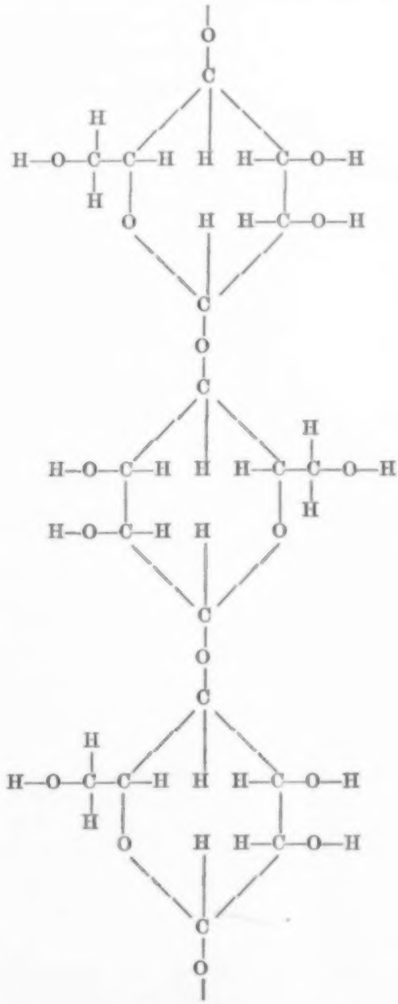

FIG. 2

will accept a proton readily. These studies lend credence to the belief that hydrogen bonds occur thus in the proteins. Spectroscopic studies of the proteins themselves are now being made and should prove fruitful, as observable effects on the vibrational bands of both NH and C=O groups are produced by hydrogen bonding.

Cellulose is made up of glucose rings arranged in chains, somewhat as Fig. 2 shows.

Studies of compounds like water, alcohols and carboxylic acids indicate that the OH group is a powerful hydrogen bonding agent. The presence of the OH groups along the sides of the cellulose chains suggests that hydrogen bonding is present and probably ties the cellulose chains into bundles, which in turn compose the cell walls of almost all plant structures. Appearing in such natural forms as wood and cotton and in such synthetic products as rayon, explosives and picture films, cellulose is sufficiently useful to justify extensive studies of the hydrogen bond theory.

Likewise, the prevalence of OH groups in biologically important compounds like starches and sugars suggests that the hydrogen bond is significant in determining their structure and properties.

In the popular Brønsted-Lowry theory, which defines acids as proton donors and bases as proton acceptors, the normal acid-base reaction is represented as the transfer of a proton from the acid to the base. The strength of an acid is defined in terms of its tendency to surrender protons to a given base, and the strength of a base in terms of its ability to capture protons from a given acid. It is extremely advantageous to think of the hydrogen bond theory somewhat as an extension of the Brønsted-Lowry theory. When hydrogen bonds are formed, proton donors and proton acceptors, acids and bases, participate, but here the proton is only partially surrendered by the acid and only partially captured by the base. Indeed, the formation of a hydrogen bond may be regarded as an intermediate step in the complete transfer of the proton. Many chemical reactions catalyzed by acids and bases are no doubt caused by a shifting of electrical charges in the molecule, a shifting which results from the formation of temporary hydrogen-bonded complexes.

It is significant that hydrogen bonding has been found to occur only when the proton acceptor atom has an available electron-pair. It appears that the proton must interact in some way with the electron-pair. There are at least two possible ways in which this interaction may take place: while remaining bound through an ordinary electron-pair bond to one of the atoms, the proton may interact electrostatically with the electron-pair or electron-cloud on the second atom; in many instances quantum mechanical resonance may be involved, in which the proton is bound through a covalent bond first to one and then to the other of the atoms, many times each second. The hydrogen atom because it has only one stable orbital can not form two covalent bonds at the same time.

Although the hydrogen bond can be studied in many different ways through its varied effects on the physical properties of substances, the most widely used method of approach is that of infrared absorption spectroscopy. As suggested above, proton donors and proton acceptors in hydrogen bonding may be considered as acids and bases. The base here weakens the bond between the acid and its proton but does not break it completely. The stronger the base, the more the bond of a given acid is weakened. Fortunately the decrease in strength of the acid bond is readily revealed in its infrared absorption spectra. For simplicity we may compare the proton vibrating against the remainder of the acid molecule to the oscillation of a

weight suspended to a spring. If the spring is made weaker, the weight vibrates more slowly, at a lower frequency. Similarly the weakening of the acid bond by the base causes the vibrational band of the acid group to shift to lower frequencies. The stronger the base, the more pronounced is its effect on the vibrational band of the proton donor group. By measurements of the shifts, estimates of the strengths of the hydrogen bridges may be obtained. Comparisons of infrared data with data obtained from measurements of other physical properties have revealed some interesting correlations.[2] For example, linear relationships have been found to exist between the shifts which several different basic solvents produce in the OD vibrational band of CH_3OD and of D_2O and the logarithms of the basic ionization constants of the solvents. These relationships promise to be extremely useful in the determination of basicity constants of numerous organic compounds, and they show how hydrogen bond forming ability is dependent upon basicity and acidity. Other relationships which have been found will likely be of value in estimating solubilities of compounds, electronegativities of atoms, chemical reactivities, etc.

Investigation of the hydrogen bond is a most promising field of research for chemists and biologists as well as physicists. Despite the large amount of data accumulated on the subject, the nature of the hydrogen bond is still somewhat uncertain. Its uses in the study of reaction mechanisms, solubilities, acids and bases, and the role it performs in biological phenomena are just beginning to be explored. Bonding through hydrogen is probably significant in the rising of sap in plants, in muscular contraction in animals, and in the transmission of messages through nerves to the brain. Recently Professor Linus Pauling has stated his belief, "As the methods of structural chemistry are further applied to physiological problems it will be found that the significance of the hydrogen bond for physiology is greater than that of any other single structural feature."[3] Something of its scope in the field of organic chemistry is suggested by the following statement of Dr. M. L. Huggins. "Many properties of organic substances which have been vaguely attributed to 'van der Walls forces,' 'polarity,' 'steric hindrance,' 'catalysis,' are definitely due to the formation and existence of hydrogen bridges. . . . The most fruitful applications of the hydrogen bridge theory will be a better understanding of the nature and behavior of complicated organic substances such as gels, proteins, starch, cellulose sugars and other carbohydrates, chlorophyl, haemoglobin and related substances, etc."[4]

As electrons, smallest units of negative electricity, tie atoms together to make molecules, so the proton, smallest unit of positive electricity, ties molecules together to make super-molecules. And with new instances being constantly discovered it begins to appear that the hydrogen bond is second in importance only to the electron-pair bond.

[2] W. Gordy and Spencer C. Stanford, *Jour. Chem. Phys.*, 9, 204 (1941); W. Gordy, *Ibid.*, 9, 215 (1941).

[3] Linus Pauling, "The Nature of the Chemical Bond," Cornell University Press, Ithaca, N. Y. 1939. p. 265.

[4] M. L. Huggins, *Jour. Org. Chem.*, I, 407 (1936).

SOCIOLOGY AND THE OTHER SCIENCES

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Most scientists, including many sociologists, believe that the theoretical and practical problems of sociology are more "difficult" or much less well systematized than is true of some other social sciences such as law, economics[1] and even political science. Most scientists would agree that the physical and biological sciences are vastly superior in this respect to all the social sciences.

I have long believed it both plausible and profitable to deny both of these views.[2] The case for the maturity of law, economics and politics is easily destroyed by considering the present war of words in these fields. In recent years, neither their practical recommendations nor theoretical formulations have been particularly convincing to a world floundering in legal, political and economic confusion and disaster. Much of what has passed, and still passes, for scientific knowledge in these fields is mere verbalized hunch and hope, fear and hate, and speculative constructs of the tongue in bondage to the culturally conditioned gut. More conventionally stated, these formulations are not the result of empirical research but are the expression of the ideologies, the folkways and mores, the personality and culture patterns of their originators. They are the projective, reified verbation of impatient, fearful or hopeful men. The ideologies of Marxism, Nazism, Capitalism, Democratism, etc., are more like religion than science. As yet, law, economics and politics have produced few valid scientific universal generalizations; they are the verbal, valuational handmaidens of particular -isms, the hortatory spokesmen of going, growing or dying legal, political or economic structures.

Actually, there is no such social reality as a legal, political, economic or even a politico-economico-legal order. Social reality is an organic compound of these and a finite number of other distinctive interacting factors. Perhaps the greatest single theoretical contribution of sociology is its emphasis that all single-factor analyses of social phenomena are inadequate. The evidence for this statement is the development of sociological jurisprudence, institutional economics, cultural anthropology, social psychology, social history, human geography and even sociological interpretations of religion, graphic art, literature and music. This *organic cultural interaction* concept of social phenomena is one of the major historic revolutions in human thought, ranking with gravitation, evolution, the cellular hypothesis, synthetic chemistry, endocrinology, immunology, radioactivity and physical relativity. It takes time for such revolutionary conceptions to register their full effects. We have not realized as yet all the implications of this organic interaction concept, not only for the social sciences but for all other sciences as well. I already have indicated some of its marked effects upon the social sciences; its effects upon the biological sciences are not so obvious and many would deny that it has had any on the physical sciences. Space prevents more than a brief discussion of these points.

The organic cultural interaction the-

[1] V. Pareto, "The Mind and Society," New York, 1935, holds that jurisprudence and "pure" economics are the only social sciences which are at all exact and well developed (Sec. 824, 2011).

[2] Read Bain, *Social Forces*, I, December, 1929, 222–231; II, March, 1930, 369–378; *Publ. Amer. Sociol. Soc.*, August, 1932, 155–164.

ory of human behavior has wrought havoc with some of the once generally accepted biological theories. One need only mention its effect on the doctrines of instinct, race differences, psychosomatic diseases, natural selection, evolution applied to human groups (social Darwinism), rampant eugenism, hereditary traits[3] and all forms of biological determinism. In this revision, many biologists took the initiative and psychology also played a part—but it was a sociologized psychology. *Tiersoziologie* and plant and animal ecology have been crossfertilized by sociology with mutual benefit. Sociologists have been greatly helped in developing their theory of organic cultural interaction by such men as Pavlov, Freud, W. M. Wheeler, Child, Allee and many others. At least the last three are also directly indebted to sociology. All science is interdependent, but it is evidence of the theoretical power of this basic sociological concept that it could utilize the work of men as apparently far apart as Freud and Pavlov and make improvements upon both. Sociology, along with astronomy and many other sciences, is indebted to Euclid, Bacon, Maxwell, Bunsen, Mendelyeev and thousands of others in many fields. The principle of organic cultural interaction and interdependence is well illustrated by the development of natural science and by all other institutionalized behavior.

Sociology has not directly influenced physical science as much as it has biology, but similar effects can be noted. Accumulating scientific knowledge of diverse cultures destroyed all types of extreme geographic, geologic and climatic determinism. The development of human geography has been mentioned. The greatest effect, however, is probably indirect. All physical problems are always aspects of the culture in which the physical sciences exist. It is the solution of culturally determined practical problems which give rise to "pure" scientific questions. The technological and ideological changes thus brought about modify the culture which in turn modifies the theoretical and practical work of physical scientists. Thus, the reciprocal scientific interrelations between the cultural, biological and physical sciences, whether "practical" or "pure," can not be denied. It takes a specific kind of culture with a certain kind of implicit or explicit values to endow a Faraday or a Millikan. Showing the cultural origin and interaction of these values modifies them, and this in turn modifies the problems of the physical sciences as well as the means available for their solution.

Perhaps this organic interdependence of the cultural and physical sciences can be made clearer by considering the concept of relativity. Cultural relativity is much older than physical relativity, having been suggested by Xenophanes, more or less clearly expressed by Ibn Khaldun, and made explicit as a scientific principle by Comte. Comte's idea was still-born into a culture where the remnants of a metaphysical voluntarism were fighting a losing battle with the waxing cohorts of mechanistic determinism. During the latter half of the nineteenth century, social scientists made a futile effort to apply an oversimplified, unilinear evolutionary theory to societal phenomena. The more they learned about their data, however, the more futile the effort became. The result was the proliferation of atomistic monographic studies which introduced into the field of social investigation a kind of cultural relativity little short of theoretical anarchy. Any attempt to construct general theories by which the mounting monographic knowledge could be ordered and interpreted was flouted either as armchair philosophy or the metaphysical vaporing of disordered minds. The crash of ambitious

[3] Knight Dunlap, Scientific Monthly, September, 1940, 221–225.

systems, constructed largely from speculative hunches rather than from empirical research, left a litter of verbal debris among which a few pariah theorists wandered all forlorn, muttering incomprehensible phrases to each other, or more often to themselves. Natural scientists in all fields ignored or jeered them; many of the theorists retaliated by a feckless rejection of all positivism, calling it mere planless empiricism, atomistic monographitis, pseudoscientific busy work. Some advocated a return to Plato and Aquinas. The old partially exorcised ghosts of medieval psychic entities began to walk again, and their fleshly advocates began to mutter in awed voices that "man is more than molecules," "mind is a great mystery," "there is *Something* more than energy," "you can't change human nature," "you can't predict human behavior." Being aided, no doubt, by extra-sensory perception, they began to hear again the flutter of mystical wings.

Many physical and biological scientists gladly accepted this point of view, and some still retain it even after most social scientists have wholly accepted the view that social phenomena are natural phenomena and the social sciences are natural sciences. Some eminent physicists still look for souls or spirits and assert that they find them; some eminent biologists still believe in mental telepathy, clairvoyance, souls and an innate moral sense; some assert that the social sciences are not, and because of the intrinsic nature of their data never can become, "real" sciences. It is difficult to understand how physical and biological scientists "get this way." An unkind guess might be that they have a vague childish fear that the prestige of their own fields somehow would suffer if they accepted the social sciences as legitimate rather than bastard. A kinder guess is their ignorance of the facts and methods of the social sciences and their general contempt for the philosophy of science. Some of them are doubtless motivated by the unconscious desire to preserve the comfortable security of their folk attitudes and their traditional biases and prejudices in all matters social. Being compelled to challenge the folk knowledge that is inconsistent with the findings of their own sciences, they wish to be conventionally respectable in their social folklore and not be bothered by having to do any scientific thinking about societal phenomena. "Others they have disturbed, but they themselves they would not disturb."

When the concept of relativity was broached in physics, some scientists, even physicists, regarded it as final "scientific" proof that the ghost-makers and spirit-seekers were right; that the principle of causation was false; that prediction was impossible, even in physics; hence, it was folly to think one could predict in the much more complicated field of social phenomena. Radioactivity and subatomic physics strengthened these views. If you can not predict when, or how far, nor tell why, an electron will jump, is it not absurd to think you can tell what a human being will think or do, or when he will do it, to say nothing of why? It is needless to say Planck and Einstein never subscribed to such views.[4] To say that such anarchy, indeterminism, "free will" or noncausality is proved by the "new physics" is not only nonsense, but "objectionable nonsense," as Einstein said (page 201 ff., *op. cit.*). Such ideas are figments of pseudo-scientific minds not yet entirely emancipated from Methodism, Aquinasism, Platonism and Unkulunkuluism.

Physical relativity is based upon a postulated absolute which seems to be a convenient if not necessary inference from empirical evidence. This is the

[4] Max Planck, "Where Is Science Going?," New York, 1932. See especially the epilogue conversation between Einstein, Planck and James Murphey, 201–221.

fourfold time-space continuum.[5] The absolute velocity of light, the assumption of knowable reality external to the knowers, the principles of conservation of energy and causality are also aspects of it. Needless to say, these absolutes are also imperatives for all cultural relativity. The failure to recognize this is responsible for what I have called anarchistic cultural relativity. When this is recognized, cultural relativity becomes consistent with predictive generalization and the statement of valid universal principles. Social phenomena are thus brought into the same frame of reference with all other natural phenomena. The real significance of physical relativity and the "new physics" is that they force us to recognize the organic interrelatedness of all natural phenomena. The closed systems of nineteenth century science are broken forever; all natural phenomena are a continuum; fixed and final entities are gone; the world is one of Becoming, not of Being; Flux replaces Finality; closed systems and all absolutes other than the derivative ones already mentioned, become methodological devices; there are no more "givens," but only "takens,"[6] and the latter are meaningful only within their "taken" frames and their carefully stated limits; conservation of energy really means transformation of energy; simplistic causation gives way to the idea that all antecedent events are operative in each occurring event—*the* cause means the manipulable variable, or the immediate precursor of an observed object or action; all events are determined, but the universe and every contained segment of it are indeterminate, unfinished, changing; there is no "far-off divine event toward which the whole creation moves"—not even the entropy of Clausius, for as Arrhenius pointed out long ago,[7] if we assume an infinity of time, as we must, universal entropy would have been reached an infinity of years ago or an infinity of infinities ago. There is no such thing as creation; there is only *creating*, the incessant transformation of energy systems. The universe appears to run *up* as well as *down;* or more accurately, the energy dissipated in one system or segment is equal to the energy aggregated in other segmental systems; integration equals disintegration. This has long been observed in social systems, *e.g.*, when one culture or civilization "falls," another "rises," when one leader passes, another appears, etc. It might be called the principle of Societal Conservation, or Succession. It seems equally true of all biological and physical systems.

The result of these changes in the thoughtways of science is a growing theoretical consensus among all scientists. This has come about, not by social scientists accepting the crude mechanistic determinism and closed-system views of nineteenth century physicists and biologists, but because the latter have recognized that their data are similar in nature to social data. The principles of organic interaction of all natural phenomena and relativity have put unity into the universe and made possible and inevitable the all-encompassing unity of science. Even though it still shocks some animistic-minded persons, we see societal data rapidly being brought into the general framework of natural science. "This too, too solid earth" has melted: matter is energy; mass is mostly volume with relatively greater distances between the constituent units (nebulae, stars, molecules, atoms, electrons) than is the case with social masses and their

[5] Planck, *op. cit.*, 195–199.

[6] John Dewey, "Logic, The Theory of Inquiry," New York, 1938, 124, 224, 522.

[7] Svante Arrhenius, "Worlds in the Making," tr. H. Borns, 191 *ff.*, New York, 1908. Entropy increases in stellar systems but decreases in nebular systems; the transformation of cosmic energy is reversible. Millikan has suggested the same thing in connection with cosmic rays.

biophysical units (cultures, nations, groups, persons). Each electron must now be conceived as a unique variable with varying charges, positions, movements and relations to other electrons; I suppose the same would be true of the energy quanta themselves. Physical "constants," like those of biology and culture, are only conceptual constants, and can be treated as such only for certain purposes, in a specified set of relations, and within clearly defined limits. All the "constants" and "stable" factors in nature are so only within the "system" in which they are "taken"; all the predictions of science are probabilities; natural phenomena, even in the most severe experimental set-ups, never occur *exactly* in accordance with the conceptualized descriptions which are scientific "laws," "principles," hypotheses. A world in flux is a precarious, problematical world of constant energy transformations; the world of science is a world of constantly increasing approximations to accurate description of what is going on—and these descriptions must always be *relative*, must be "taken" in relation to something. In this kind of a world, persons are not so uniquely unique as many people still like to think. Every item of experience in the universe is unique with a uniqueness that varies from instant to instant. When physicists and biologists actually and vividly realize this, they are likely to have a greater fellow-feeling for social scientists.

No segmental system, and all systems are segmental, including Einstein's finite but unbounded universe, can be treated realistically as closed; methodologically, it can, and I think of necessity must be so treated, but this is merely a convenient scientific device which has been found highly useful. The incessant constructive and destructive changes within and between all (relatively) separate "taken" systems, including the entire universe, which is also a "taken" system, render the concept of a closed system meaningless; this is also true of all "stabilities," "gestalten," "perdurable entities" and all fixed and final energy systems. While social scientists developed the concepts of organic interaction and relativity which have been found equally applicable to physical and biological reality, physicists and biologists have developed the best methods of dealing scientifically with such reality. Thus, the ontology of social science has converged with that of the physical and biological sciences, while the social sciences are rapidly taking over the epistemology and methodology of biology and physics. Physicists and biologists are now beginning to see that it is slightly silly to say "you can't change—or predict—human behavior" when it is becoming obvious that everything in nature can not do anything but change. It is also true that men have always predicted human behavior on a common-sense level, just as they have similarly predicted physical and biological behavior. Now it is beginning to be equally obvious that *scientific* prediction of human behavior is possible for the same reasons and by the same general methods that have made it possible to predict physical and biological occurrences.

Physicists and biologists are also beginning to realize that many social scientists are as conversant with natural science ideology and methodology as they themselves are. All natural scientists, including social scientists, are beginning to talk the same language. Ghosts, entelechies, emergent evolutions, "there is something *different* about man," "the mystery of life and mind," the magical mindedness of the jungle, the mystical occultism of the medicine man and the priest, the personification and reification of abstractions, are now rapidly disappearing from the social sciences. The

great lurking places of these prescientific ideas, especially as they apply to social behavior, are the compartmentalized minds of some physicists, biologists, old-fashioned social "scientists," the scientifically illiterate minds of politicians, priests, artists, publicists, etc., and the untutored masses.

One effect upon many minds of the world picture above described is a loss of faith in natural science. The quest for certainty[8] seems a hopeless quest and it has become fashionable in some quarters to sneer at science. There is a revival of the religion of the irrational, aided even by some scientists, *e.g.*, Lodge, Eddington, Carrel, McDougall, Rhine, etc.,[9] the growth of Holiness religions, New Thought, divine healing, to say nothing of the economic and political big medicine of Communism, Nazism and private-profit Capitalism. The serious scientist, especially if he is a social scientist, who is critical of the current cults of his culture is suspect in all countries and is "concentrated" in many. This all-encompassing pressure of the irrational threatens the integrity of all scientists in all fields in all countries. There are none, or few, who entirely escape its distorting influence. Social scientists are probably more immune to it than physical and biological scientists because they know vastly more, though their *scientific* knowledge is still meager, about how and why persons and groups behave as they do.

This brings us face to face with the scientific problems of sociology. Essentially, they are the same as those of all the natural sciences. The specialist in all fields is the inheritor of a more or less systematized body of facts and principles, a number of problems and a set of mental and physical techniques for solving them. Of course, all three of these factors are variables and subject to great temporal and spatial changes. All scientists have in common the generalized concept of the organic interaction and continuity of all natural phenomena and the consequent concept of relativity; they also have the highly developed natural science methodology; finally, they have the faith that scientific knowledge is "good" because in the long run it aids man in his struggle for survival and what we somewhat vaguely call the "good life." If a scientist lacks this faith, his work becomes mere puttering busywork or a petty racket. Another thing all scientists have in common is the frequently stated but unsound distinction between "pure" and "applied" science.[10] The only real distinction I can see between them is their temporal orientation. The applied scientist wants usable results at once; the pure scientist is willing to wait, being sustained, perhaps, by a faith in the ultimate usefulness of all scientific knowledge. His immediate interest is the solution of the scientific problem; he believes it is worth solving because it sometime will be useful in solving man's practical life problems, one of the most insistent of which is his itch to *know*, to adjust himself to the kind of world he seems to be living in. There is considerable evidence that this scientific faith is justified by its results. Many practical applications of

[8] John Dewey, "The Quest for Certainty," New York, 1929, especially 204–222 for the disturbing effects of the new science. The whole book is a discussion of the way out of uncertainty—which is the way of probability natural science. *Cf.* Chapter IX, "The Supremacy of Method." See also Part IV, "The Logic of Scientific Method," in "Logic," cited above.

[9] They do not attempt to "prove religion" by science, as Eddington says in his reply to his critics ("New Pathways in Science," New York, 1938), but they make statements that have no scientific basis which give aid and comfort to the animistic folk mind of the masses. The prestige of their names becomes "proof" for all sorts of nonsense which uncritical minds want to believe.

[10] John Dewey, "Experience and Nature," 162–165, New York, 1925, suggests that any science that is not applied, or applicable, is really "impure" or nonexistent.

what appeared to be the purest of pure science are quickly made; on the other hand, many revolutionary discoveries have been made as by-products of applied science, and the findings of practical, even "commercial," scientists and engineers are constantly adding to the cumulative body of "pure" sciences.[11]

In sociology, the situation is the same. Practical problems, or social problems, give rise to sociological, *i.e.*, scientific, problems which may be called practical or applied sociology. Such research is reciprocally related to pure sociological research and may advance it as much as pure research may aid in the solution of social problems. A social problem may be defined roughly as behavior which is or is thought to be detrimental to the welfare or existence of the group. In Pareto's terms, it is probably a derivation from the residues of group persistence, sociality and equilibrium.[12] It is an aspect of the mores, or collective values, of the group. A social problem in one culture may be nonexistent in another culture or in the same culture at a different time. Scientists, or any other distinguishable class, may regard a certain type of behavior as a social problem, or a more serious one, than it is judged to be by the majority. For example, many Americans regard the adulteration of food as a more serious social problem than the adultery of spouses, though the great majority regards such an idea as shocking and absurd. The same may be said of bank robbing and bank wrecking; white-collar criminality and murder, rape, arson or kidnapping; excessive profits and excessive drinking; lack of proper sex education and prostitution; and so on. Social problems arise and disappear through changes in population, natural resources, technology, science and institutional organization, which modify the folkways and mores.[13]

Sociological problems, whether pure or practical, are defined by the culture. Even when the scientific problem is "purest," that is, a nonutilitarian expression of the scientist's desire to *find out*, to order and/or understand his universe (*verstehende und ordnende Wissenschaft*), the scientist believes its solution will have ultimate use. However, most scientific problems are and should be practical, that is, relevant to immediate and pressing problems of personal and societal adjustment.[14] There may be widely different opinions as to what are desirable adjustments; the application of scientific knowledge may produce results vastly different from what the scientist or the public expected; the long-run effects may be "detrimental" rather than "beneficial." On the whole, however, none of these things have been true, and the more specific the problems have been, the fewer have been the unexpected and undesired results. While all practical problems are functions of specific cultures, there are some which are almost universal, such as the desire for long life and good health, adequate food, shelter and clothing, more recreational and art facilities, improved transportation and communication, the control of crime, protection of persons and property, and in recent years, the extension of science and education as a means of implementing these objectives.

[11] Randolph T. Major, SCIENTIFIC MONTHLY, August, 1940, 155–164.

[12] V. Pareto, *op. cit.*, sections 991–1088 (persistence), 1113–1206 (sociality) and 1208–1331 (equilibrium).

[13] I have discussed these inconsistencies in values in *Sociology and Social Research*, January–February, 1935, 266–276, and their relations to conflict and control in *American Journal of Sociology*, January, 1939, 499–509.

[14] W. F. Ogburn in "Essays on Research in the Social Sciences," "Considerations in Choosing Problems of Research," 161–171, Brookings Institution, Washington, D. C., 1934. The whole volume is very useful. See also Robert S. Lynd, "Knowledge for What?," Princeton, 1939; also J. Dewey, *op. cit. supra.*

Experience shows that "pure" science is of the greatest importance to the development of applied science. If pure science is neglected, or denied a free and wide-ranging opportunity to explore, the whole structure of science is threatened.[15] Mere applied science, if there could be such a perversion of science, would soon result in scientific stagnation. As has been pointed out, the reciprocal interdependence of the "pure" and "applied" is so close that any discussion of their relative importance is impertinence. Both are indispensable and inevitable. In the case of sociology, the shortest road to scientific respectability and public prestige is emphasis upon practical problems such as prediction of marriage and parole success and failure, the prevention and cure of crime and juvenile delinquency, the Negro problem, population and health studies, etc. However, it is also obvious that the solution of many "pure" sociological problems such as the construction and refinement of appropriate instruments and techniques, analysis of the structuring and functioning of plurels, the definition and classification of societal phenomena, etc., is not only necessary for the solution of practical problems but is also a prerequisite for attaining the scientific respect of our physical and biological brethren. The reciprocal interdependence of pure and applied science is axiomatic.[16]

All natural science may be classified as either theoretical or empirical. One may do research in either field. Such research is as organically reciprocal as pure and applied research. The general pattern of empirical research is well defined in the physical and biological sciences and is rapidly being applied to research in the social sciences. It may be merely descriptive, classificatory or comparative; it may be qualitative or quantitative; ideally, it should be instrumental, quantitative and experimental. In any case, it must be based upon sensory experience which is public; that is, the data must be copious and accessible to any properly equipped person so that the research can be repeated. This is essential for verification, both of hypotheses and data. This is so elementary, it does not merit further discussion.

Theoretical sociology, however, merits a great deal of discussion—more than space permits. I have indicated above that it is and has long been in disrepute among empirical scientists. This is a good sign of the development of sociology into a natural science. The low estate of theoretical sociology is due to the fact that very few social theorists have properly conceived their function. By and large, they have been literary men or historians rather than scientific theorists. They have conceived their function as the rehashing of the verbal hash of ancient men of commonsense and insight who made some speculative remarks upon man the social animal, or man the masterpiece of the Almighty. They have resurrected many almost forgotten minor men and made scholarly reputations by citing hundreds of unknown names. They play games with each other over the relative merits of Polybius, Ibn Khaldun, Plato, Aquinas, Aristotle, Machiavelli, Montesquieu and Vico, to say nothing of men more recently dead, and they tend to accept or reject the results of empirical research in terms of whether or not their particu-

[15] Abraham Flexner, "The Usefulness of Useless Knowledge," *Harpers Magazine*, October, 1939, 544–552.

[16] Lester F. Ward's first chapter in "Applied Sociology," New York, 1906, is still one of the best statements of this. John Dewey's views about the importance of choice is similar to Ward's position. Ward, like Comte, was more or less confused by the conflict between the mechanistic and voluntaristic points of view. A. N. Whitehead, Dewey and others have supplied a philosophy which more or less resolves this conflict.

lar pet said, or, in the lingo, "adumbrated," it. It is remarkable what can be found in the works of these ancient worthies. There have been hundreds of doctoral dissertations in psychology and sociology, to say nothing of religion and literature and what have you, on Thomas Aquinas's Doctrine of This or That. The only thing comparable to what social theorists can find in the works of the worthies is what politicians can find in Washington's "Farewell Address," what judges can find in the Constitution and John Marshall's exegesis and *obiter dicta,* and what theologians have found in the Bible.

Social theory will continue in its present merited low estate until this bondage to the book, this modern scholasticism, is broken. A new breed of social theorists must arise in the land. If the ancients are studied at all, it should be chiefly to point out their ignorance and stupidity, not to worship and adore and take modern rabbits out of those funereal Black Hats; to show us how far we have come, not that we should return to these alleged founts of all wisdom. Social theory must become something more productive than antiquarian ardor, more creative than textual criticism and more stimulating than wordy rehashing of wordy hash. If this is what the sociological theorist has been and should not be, what would he be and do if he were a productive scientific worker?

He should have a sound training in the methods of physical, biological and cultural research and a wide knowledge of the findings and theoretical structure of these fields. He should be learned in the history of science and culture but should not be a historian. He should have some experience with empirical research. He should be literate in philosophy and mathematics and skilful in logic. Above all, he should possess a critical, creative, generalizing type of mind. His function should be to criticize, interpret and systematize empirical research, particularly in relation to the findings of the other social sciences but also to those of physics and biology.[17] He should be skilful at making explicit the implications of specific researches, pointing out deficiencies and suggesting remedies. He should be able to help the empirical researcher define his problems so as to give them the greatest possible scientific significance. He should be conscious of the gaps and weaknesses in the structure of the science and be fertile with suggestions for improvement. He should be an alert critic of theoretical statements and specific hypotheses that are incapable of empirical test, and aid in their restatement or final rejection. His business is to improve the accuracy and efficiency of the technical vocabulary of the science, but he must not confuse archaism and neologism with scientific terminology, verbal quibbles with substantive meanings, nor reifications with methodological abstractions. He should have a wide-ranging, well-stocked mind, which secretes useful hypotheses as the liver secretes bile. In short, he should be a well-trained natural scientist with the kind of daring, creative, factually disciplined imagination which sees relationships and implications that many careful routine researchers do not see. Most research is a routine technical matter, though it requires a high degree of specialized skill. It furnishes the cumulative knowledge out of which eventually come the synthesizing revolutionary generalizations of science. The theorist is an indispensable functionary in the

[17] The kind of systematic social theory I am talking about is exemplified by G. A. Lundberg, "Foundations of Sociology," New York, 1939, and S. C. Dodd, "The Dimensions of Society," and a considerable amount of writing in the journals. This new social theory is not characterized by the fact that it is "sound" or "true," but by the fact that it is oriented toward the natural science conception of sociology. The test is not so much where it gets as the direction in which it is going.

institutionalized structure of science. In rare instances, we may find a great empirical researcher who also is a great theoretician, a Darwin, a Newton or possibly a Pasteur, but more frequently these specialized functions are not found in the same man. Maxwell, Einstein, Comte, Spencer, Ward, etc., were not particularly noted for empirical research.

There is grave need for this new type of social theorists. Such persons probably are partly born and partly made, but we have paid little attention either to finding or training them. The graduate students who specialize in "social theory" are still largely taught the history and exegesis of what is euphemistically called the sociological literature. Every department that trains many graduate students or does much research, and every large research project funded by foundations or government agencies, should employ one or more social theorists such as I have described. They should be especially valuable in the training of students, in the preliminary analysis of research about to be undertaken, and in the preparation of final reports.

Probably there is not a dozen such social theorists in the entire United States; certainly, not enough to staff the research and teaching we are doing. Most of our so-called social theorists have not yet accepted the simple proposition that social phenomena are natural phenomena and sociology is a natural science. If they have accepted it verbally, they have not realized its logical and research implications. Consequently, they still are wandering in the ancient wilderness of fuzzy words. Many empirical research men have accepted and are practicing this simple proposition—and they are producing scientific results. When the tradition of sociology as natural science is old enough and its cumulative scientific results are great enough, doubtless the Newtons, Daltons, Maxwells and Einsteins of sociology will appear.

ROYAL PATRONS OF SCIENCE

With the death of Ex-Kaiser Wilhelm II of Germany at Doorn in Holland, at the ripe old age of 82, a notable personality disappears from the arena of contemporary history. He will be viewed in various colors by posterity, but science will remember him as the main initiator and founder of the group of scientific research institutions in Germany known after his name. An account of the activities of these research institutes will be found in *Science and Culture*, Vol. 1, pp. 161, 175 and 332, 1935–36. These institutes were founded some time before the World War of 1914 and have been responsible for such epoch-making research works as the Haber process for synthesis of ammonia, production of synthetic rubber, new alloys, liquid fuel out of coal and lignite, etc. The Kaiser took personal interest in the foundation of these institutes, and secured funds from the state and industries. In spite of the revolution of 1918, which overthrew the monarchy, the institutes rightly continued to be called after him. The Kaiser probably imbibed his appreciation of the importance of science to national life from his maternal grandfather, Prince-consort Albert, husband of Empress Victoria. The Prince was mainly responsible for encouragement of science in England about 1850. It was through his endeavors that the International Exhibition of 1851 was held at the Crystal Palace and the Victoria and Albert Scientific Museum was founded at South Kensington, and steps were also taken for the foundation of the Royal College of Science in London. The Prince was not much liked during his life time, but his services to England are being appreciated more and more as England is awakening to the importance of science in modern life.—*Science and Culture, July, 1941.*

SCIENTIFIC KNOWLEDGE IN HISTORICAL CRISES

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AT the time of a great crisis, when organized society suffers from deep physical and emotional strains, the elements underlying human nature are revealed in their starkest and most poignant form. A terrible catastrophe tears away the cover of graces and conventions from civilization, disclosing the ignoble promptings of man as he stands alone in a fury of fear and brutality. The picture is not a pleasant one, for the lack is clearly shown of fundamental principles of justice and of the social considerations that civilization has built up.

Yet there are golden threads in the baser fabric. Human nature is not entirely selfish and panicky. Courage and generosity are ingrained in the superior types of men and women. The noble characteristics of idealism and chivalry are based on innate impulses of the human heart. Recent troubles in Europe have revealed these mixed promptings of man's nature, but Europe has seen worse crises than these.

Perhaps the most dreadful and spectacular of all afflictions that ever befell civilized society was the Black Death of the fourteenth century. This devastating epidemic ravaged Europe, Asia and part of Africa about 1348, and killed millions of people—in Europe perhaps a quarter or a third of the population. In many regions over half the people died within a few weeks, and the terrified survivors lived momentarily in fear of a similar end. Such a deadly scourge seemed like the end of the world to many dazed communities. They had never known anything like it and assumed that it was a visitation sent from God or the Devil.

Hundreds of villages were entirely depopulated and deserted. The dead rotted in the streets; corpses clogged the rivers; the afflicted moaned without attendance or help. Families separated in terror when one or more members showed symptoms of the disease, and many were never able to find their loved ones again. Cattle and horses wandered in the fields unnoticed. Ships full of corpses coursed idly on the waterways with no one to steer them. A gripping fear fell over the civilized world; apparently God had forsaken His people.

Probably the deadly outbreak began in Asia, the traditional breeding place of disease. Famines and earthquakes, which left decaying corpses to poison the air and water, were at one time thought to be responsible. Actually rats and their fleas were the chief factor in its origin and spread. Modern theories as to the causes of an epidemic that took place before the discovery of America, when the science of medicine lagged and observers were generally too terrified to record data, are necessarily based somewhat upon conjecture and upon general knowledge of Asiatic epidemics as they have been studied in later years. The Black Death was a form of the bubonic plague, to which Europeans were unaccustomed at that time. To-day we guard against foreign rats, with their disease-laden fleas, especially at seaports.

The trading routes around the Black Sea were early affected, and from the markets of Constantinople the germs were diffused over Europe, partly by

overland travelers and partly by ships. The rapid spread and the extreme virulence indicated that it was an unfamiliar disease against which the constitution of man had aroused no resistance, for the human body has the faculty of building up counterworks against ailments to which it has had a chance to accustom itself. In this case there were no protection and no reserves. Medicine and health regulations gave no relief. What knowledge the physicians of the time possessed was helpless against the sweep of this swift messenger of death. We still have bubonic plague, but it is not so virulent, or else our bodies are less vulnerable. Perhaps we are healthier than our ancestors of six centuries ago, or at least better protected in sanitation and medical inspection.

The symptoms of the Black Death varied somewhat in the different localities, but had common likenesses. Inflamed boils and swellings appeared on the body, especially in the armpits and groin. The black spots, indicating dark blood or putrid decomposition of the flesh, were generally accompanied by spitting or vomiting of blood. The afflicted one died quickly, despite anything that could be done.

The Italian writer, Boccaccio, recorded that in Florence he saw two pigs pry around the clothing from a stricken man which had been thrown into the street. The pigs soon staggered as though poisoned and fell dead upon the infected rags. In some cities the streets were periodically cleared of corpses, which were piled in rows of thousands in pits outside the walls.

One of the most interesting aspects of the Black Death is the record of the measures taken by the medical men of the time to combat the disease. Such a study reveals vividly the state of science in the fourteenth century and throws light upon the subterfuges of the professional mind when it is pressed for results beyond its ability and knowledge. The most celebrated medical organization in Europe was that at Paris, and naturally it was asked to formulate rules for resisting the dreadful plague that was ravaging Christendom. The doctors were required to be wise at command.

The reply of this medical faculty began gravely as follows: "We, the Members of the College of Physicians, of Paris, have after mature consideration and consultation on the present mortality, collected the advice of our old masters in the art, and intend to make known the causes of this pestilence, more clearly than could be done according to the rules and principles of astrology and natural science." This was a brave beginning, which shifted attention to the "old masters" and the faults of astrology. Rats were not even suspected, and fleas were too common to cause worry.

The document then went on to say that vapors, aroused by the heavenly bodies over India and the Great Sea, corrupted the water and air so that even fish died. Vapors were accused of carrying diseases as late as 1800. The fact that the sun was in the sign of Leo in the zodiac was considered an especially bad influence. In general, however, these learned professors believed that the constellations were striving to protect the human race and might succeed in breaking through the mist, thus converting it into "a stinking deleterious rain, whereby the air will be much purified." As soon as this rain began to fall, the people were warned to protect themselves by kindling large fires of green wood and not to go into the fields again until the earth was completely dry. Vapors, not rats, seemed to be the enemy.

Other learned directions promulgated by the organization were:

Poultry and water-fowl, young pork, old beef and fat meat, in general should not be eaten; but on the contrary, meat of a proper age, of a

warm and dry, but on no account of a heating and exciting nature. Broth should be taken, seasoned with ground pepper, ginger and cloves, especially by those who are accustomed to live temperately, and yet are choice in their diet. . . . Beet-root and other vegetables, whether eaten pickled or fresh, are hurtful; on the contrary, spicy pot-herbs, as sage or rosemary, are wholesome. Cold, moist, watery food is in general prejudicial. . . . Only small river-fish should be used. . . . Rain-water must not be employed in cooking, and every one should guard against exposure to wet weather. If it rains, a little fine molasses should be taken after dinner. . . . Olive oil as an article of food, is fatal.

The Parisian authorities warned against lettuce, but Southern doctors recommended it.

The admonitions about diet were conflicting and puzzling. If they were adopted at a conference, perhaps each physician insisted that his particular regulation should be included, so that as a consequence all the physicians were satisfied but the patients were overwhelmed and confused. If the physicians differed as radically then as now about diet, it is no wonder that the patients were mystified and gained little of value from the variegated directions. Perhaps these fourteenth-century physicians, knowing that they were up against a difficult problem, made their recommendations purposely vague and intricate, in order that, when no great benefit followed, they could ascribe the failure to the misinterpretation or neglect of some detailed rule. Such a device is not unknown even to-day.

On the subject of drinking, the group had this to say:

At breakfast, one should drink little; supper should be taken an hour before sunset, when more may be drunk than in the morning. Clear, light wine, mixed with a fifth or sixth part of water, should be used as a beverage. Dried or fresh fruits, with wine, are not injurious; but highly so without it. . . . Good clear wine should be selected and drunk often, but in small quantities, by day. . . . Equally injurious are fasting and excessive abstemiousness, anxiety of mind, anger and immoderate drinking. Young people, in autumn especially, must abstain from all these things, if they do not wish to run a risk of dying of dysentery.

Although much of this advice about drinking is harmless enough, other items do not encourage confidence in readers who try to analyze what the doctors were aiming at. The author of the curious old book "Epidemics of the Middle Ages," Professor J. F. C. Hecker, M.D., of Frederick William's University of Berlin, suggested that this distinguished medical group at Paris

found themselves under the painful necessity of firing a point-blank shot of erudition at an enemy who enveloped himself in a dark mist, of the nature of which they had no conception. In concealing their ignorance by authoritative assertions, they suffered themselves, therefore, to be misled; and while endeavoring to appear to the world with eclat, only betrayed to the intelligent their lamentable weakness.

Such frankness from a fellow physician is commendable. Perhaps the fact that he wrote nearly five centuries afterward and that the medical faculty had been at Paris, rather than in his beloved Germany, prompted him to speak openly. If more members of the learned professions would speak up critically and pointedly about their mistakes and lack of knowledge, a tremendous amount of good would result. But they should not confine their criticisms to the members of the profession in foreign countries, and should speak up sooner than five centuries after the event.

Before leaving the subject of the recommendations by the doctors at Paris, it is interesting to quote their preventive precautions against the plague. For example:

Sleep in the day-time is detrimental; it should be taken at night until sunrise, or somewhat longer. . . . Going out at night, and even until three o'clock in the morning, is dangerous, on account of the dew. . . . Too much exercise is harmful. [Exercise caused excessive inhaling of the infected air, it was believed.] The body should be kept warmer than usual, and thus protected from moisture and cold. . . . Fat people should not sit in the sunshine. . . . Bathing is injurious. [Bathing opened the pores to

the air.] Men should preserve chastity as they value their lives. Every one should impress this on his recollection, but especially those who reside on the coast, or upon an island into which the noxious wind has penetrated.

Medical advice from other sources was not much better than that from Paris, for of course the condition of science in the fourteenth century did not permit of a very high level of erudition. A celebrated Italian authority of the time, Gentile of Foligno (follower of Peter of Abano), believed that much depended upon proper purification of the air. He recommended large fires of odoriferous wood both for the sick and the well, and directed the latter to wash themselves frequently with vinegar or wine, to sprinkle their dwellings with vinegar, and to inhale camphor and other volatile substances. This use of vinegar and wine as antiseptics was, of course, commendable. He favored powdered emerald taken internally, also liquefied gold—rather expensive medicines.

There were numerous attempts to treat the swellings or buboes when badly inflamed. They were burned with red-hot iron or gold, sucked by leeches or cut with knives. This last means proved best, for it let out the poison most expeditiously. Bleeding was a favorite remedy; the removal of five pounds of blood cooled the body, it was believed.

Many of the physicians of the time, as well as other authorities, ascribed the Black Death to the influence of the planets—a belief which went back, of course, to the earliest theories of magicians and astrologers. The grand conjunction of the three superior planets, Saturn, Jupiter and Mars, in the sign of Aquarius of the zodiac was thought to be particularly harmful; this conjunction was said to have happened definitely on March 24, 1345. There was much scanning of the heavens for signals from God and much debating among the learned as to the exact significance of the planetary movements.

The Jews, as usual, were accused of poisoning the wells and were horribly tortured and burned in great numbers, as many as two thousand at a time. Only a few Jewish children and attractive young women were ordinarily spared during these persecutions, although some of the others gained exemption by undergoing Christian baptism. In general, the dietary and sanitary habits of the Jews were superior to the prevailing ones, and thus made them suspiciously healthy.

For comparison of modern with medieval methods of fighting bubonic plague, a recent news-dispatch from China stated that science cooperated with superstition in the province of Fukien, where thousands were dying from this ancient affliction. The local officials started a campaign to eradicate the germ-carrying rats. Serum injections were given to all of the inhabitants who would submit to them, and infected cases were isolated. Educational posters were displayed to teach the people the cause of the plague and the best means of prevention. One poster showed a large picture of a rat with the inscription, "Where there are no rats, there is no plague." Another poster depicted a dead rat with fleas the size of eggs jumping from it to a live rat. From the live rat some of the fleas were shown transferring to a woman victim.

Along with these modern methods, many old superstitions still lingered among the Chinese people. Children wore pieces of dried marrow and other amulets on strings around their neck. On the doors of houses were hung scrolls inscribed with magic Chinese characters to charm away the disease. A popular theory was that the epidemic had been sent to the earth in a plague-boat dispatched through the air by evil spirits. To ward off this plague-boat, outdoor theatrical performances were held, and paper boats were ignited and launched into the air. In one district, terrified

peasants consulted the priests and were told that the year was a plague year. They decided to set the calendar ahead and start a new year with all the usual New Year festivities. Such superstitions are no more ridiculous than European beliefs in the fourteenth century. China is merely a few centuries behind the West in these curious ideas.

When Europe's accustomed ways of living were interrupted by the Black Death and terror stalked over the land, the regulations of society were relaxed and individual inhibitions fell away. Different personalities reacted in varied ways to such a condition. The vicious element of the community, always smouldering beneath the law-abiding surface, broke loose, and gangs of ruffians swarmed over the countryside, plundering homes and assaulting defenseless people.

Many normally sober persons, convinced that their last days were at hand, threw off restraints and resolved to get as much pleasure as possible amid the chaos around them. They roamed about, mocking at fate, drinking from tavern to tavern, and taking what they wanted from the private houses that were now more or less common property, since the owners had abandoned them or had barricaded themselves in upper rooms or in detached outhouses. It was a shameful spectacle.

As in every great crisis or calamity, many religious fanatics sprang into prominence and began prescribing their particular code of morals for others. Interpreting the plague as a punishment inflicted by God on a sinful world, they advocated austere living, with meager diet and abstention from sexual intercourse. The more extreme went about in bands, whipping one another on their bare backs to convince God that they were thoroughly punished for their sins and had heeded His warning. Such bands of flagellants persisted for years afterwards in their exhibitions, giving vent to the confirmed belief of the Middle Ages that a life of mortification of the flesh was a preparation for heaven and served as vicarious atonement in behalf of the aims of the community. Boys not yet in their teens joined these bands. Women embroidered banners for them. Revolting scenes of flogging and hysteria showed the decadence of the spirit. The world seemed to have gone mad!

Many religious-minded people were shocked by the schism in the Church of Rome and the decline in the dignity of the papacy—soon to fall into the spectacle of rival popes claiming the leadership of the Church. Conservative Christians were disturbed by the presence of the papal court at Avignon in southern France instead of the accustomed Rome. The old unity and supreme faith of the Middle Ages were disintegrated by this ecclesiastical unrest. The Black Death added to the confusion and helped to prepare the way for the Renaissance and the Reformation.

When desolation and devastation swept over Europe, many sensible persons withdrew to remote retreats in the country and lived as simply and as quietly as possible, taking along their relatives and friends when this was possible. There was in truth, little inducement to remain near the crowded centers of civilization, for anarchy had set in, and the authority of laws and the respect for human rights had broken down. Such a condition has a demoralizing effect on a community and destroys the incentive for decent people to live there. Recently certain areas in Europe have had similar experiences in the break-down of normal life.

As the Black Death became worse and infection grew more dangerous, physicians became afraid to attend the increasing numbers of sick, priests hesitated to go near them for administering

the last rites and grave-diggers threw the corpses into shallow pits or into the rivers—when they did not let them rot. The dogs ate many bodies, as food became scarce. Pope Clement the Sixth, from his seclusion at Avignon where he let no strangers approach him and kept protecting fires burning constantly, was obliged to consecrate the river Rhone so that bodies might be thrown into it without delay. "Charity was dead, and hope crushed," wrote the contemporary physician, Guy of Chauliac. All men fled from death. Avignon had been a center of gay life; it now went into mourning.

So great was the fear of infection that even a glance from the eye of a sufferer was believed to be sufficient to transmit the disease. This was in accordance with the ancient belief, inherited from pagan times, that in the process of vision, something material actually shoots out from the eye and touches what it sees. In the general confusion, frightened persons, hoping to buy immunity from contagion by gifts to God, hurried to the churches with gold and jewels. Often the priests, fearing contamination, closed the gates, whereupon the hysterical penitents threw their money and trinkets over the walls into the sanctified grounds. These were strange sights, but human nature was in terrible despair.

Many men who had lost their wives in the epidemic tried to become monks or priests, although a large proportion were illiterate. But monks and priests died as fast as the others, and some became panic-stricken and selfish. A great blow to the prestige of the Church and to organized authority in general was one of the direct results of this crisis.

In spite of the tightening of the morals of those who believed the plague to be a warning and punishment sent by God, and who were frightened into piety, a great relaxation of taboos and inhibitions followed the touch of such an upsetting infliction. Aristocratic and delicate ladies allowed themselves to be attended by rough men, who formerly they scarcely knew existed, but on whom they now become dependent. Masters fraternized with servants, for the very good reason that they feared any one from outside. A great calamity brings equality in the face of danger. Something of the old chivalry and the distinctiveness of aristocracy were lost in this mixing of classes, even as a new spirit of human sympathy grew up when men and women saw that mutual helpfulness was necessary unless all pretensions to Christian principles and civilized society were to be abandoned.

The general effect of such an overturning of social barriers and the lessening of the customary consideration for aristocracy encouraged lawlessness and disorder, just as destructive wars emphasize materialistic advantages and bring reactions against idealism. For years afterward there were numerous disputes and quarrels over legacies, and the new shufflings of classes and individuals in a decimated society required much adjustment before friction died down. Selfishness and brute force had gradually to be subdued to permit a smooth working of the amenities of law and order.

The belief that the Black Death was sent by God to frighten a sinful world into piety and righteousness is not supported by what followed, for people generally were less moral and altruistic after the event than before. Such a severe shock, coming when medieval civilization was on the wane, shattered many decaying and outworn institutions and cleared the field for modern ways. For many decades in this chaotic period, however, God seemed to have forsaken His people. There appeared no end to the misery and degradation.

The rise in prices and the increase in wages which are usually ascribed to the Black Death have been exaggerated.

It did, however, bring discontent to large sections of the working classes, and it hastened the change from feudalism to a society dependent upon money and a commercial middle class—changes which had been slowly developing previously. Landlords tended to turn their farms into pastures for sheep when they found labor for cultivating the soil difficult to obtain. These economic changes marked the beginning of the serious labor problems which periodically disturbed later developments of western civilization.

The terrific strain of such a cataclysm as the Black Death left deep imprints on men's nerves and emotions for generations afterward. Any unusual manifestations of human peculiarities were attributed to repercussions of the effects of this dangerous visitation. One of the most curious weaknesses that afflicted the human race in the period after the Black Death was the dancing mania of the fourteenth and fifteenth centuries. This peculiar nervous disease appeared in Europe shortly after the plague had ravaged the land. A few fanatical individuals would begin a wild dance in the streets or the market place of a town, and the strange frenzy would spread to the spectators until perhaps several hundred people were dancing.

These affected victims would caper madly about, screaming and foaming at the mouth. Some would cry that they saw the heavens opening above them, and that Saint Peter or the Virgin Mary was visible there. Others had epileptic convulsions, and fell to the ground panting and senseless. Some of the victims died from injuries received during their paroxysms, and many suffered from fits of nervous trembling for long afterward.

At Aix-la-Chapelle in 1374, wandering troops of men and women were seen who had streamed out of Germany under the influence of this peculiar epidemic. They formed circles, hand in hand, and danced in frenzied delirium until exhausted. Later the disease spread from Aix-la-Chapelle to other towns. Liege, Utrecht and Tongres were attacked. At Cologne more than five hundred people were possessed by the malady; at Metz eleven hundred dancers filled the streets. Peasants left their domestic duties to join the wild revels. Strassburg was visited by the mania in 1418. In Italy the delusion took the form of "tarantism," in which the victims imagined that they had been bitten by the tarantula, or they became excited at sight of some one who had apparently been bitten.

If only an occasional individual had become affected by such a nervous affliction, very little would have been heard of it. But the fact that the malady was contagious, and that hundreds of people at a time became possessed by it, made it a subject of deep concern. Why should masses of people have fallen into such a mental state that the sight of others capering about in a frantic ecstasy made them follow and do likewise? What disorder of the nerves could have been so prevalent that the streets became filled with temporarily insane people who apparently had to get a certain amount of dancing out of their systems? Why should staid peasants and respectable craftsmen have dropped their work and flung themselves about in such an abandoned manner?

Various explanations have been advanced for the curious epidemic. One theory is that brooding over religious problems at the end of the Middle Ages grew so pronounced that a reaction came in a sudden demand for violent physical outbursts. This theory is supported by the observation that many of the dancers had religious visions, and that several colonies of nuns were affected by the most extreme and perverted of the attacks. Another theory is that the repression and monotony of the saddened

life of Europe after the Black Death built up a condition of nerves that required an unconventional outlet.

Scientists have pointed out that human nature pursues periodic aberrations of strange and inexplicable courses. At intervals, fortunately not frequent, there appear evidences of peculiar states of mind that puzzle later historians. Wide-spread illusions occasionally spread over what we call the civilized world even to-day. Such an aberration was the witchcraft mania of the sixteenth and seventeenth centuries, and many of the wars of history now seem ridiculous and baseless. Some queer things have happened recently in Europe as a result of wars.

The inexplicable possibilities of human nature are almost endless, and man's capacity for irrational actions is astonishing. Dancing manias, witch hunts, and bloody wars over theological dogma or national vanity show the varied thoughtlessness of *homo sapiens*. Man can conquer his environment to an amazing degree by his inventions and scientific discoveries, but there remains his own unfathomable and unsatisfied nature that continues to puzzle wise sages. As Walter Lippmann recently said: "The human race is as yet only a little bit civilized and in time of serious trouble has a strong tendency to stampede back into barbarism."

Several other outstanding events of the Middle Ages are worth reviewing in order to show how blunders arise in civilized societies. Some of the great crises of historical times have, of course, been the decisive battles that determined what principles and what nations were to prevail. Many of these battles were dependent, not so much upon the bravery of the soldier or the strategy of the generals, as upon the invention of new weapons and the ingenious application of scientific principles. The conventional text-books do not always explain properly the full effect upon history of these inventions and devices, as historians are sometimes lacking in understanding of science and engineering. The topic is a timely one, since modern innovations are revolutionizing warfare.

The tendency of the traditional types of human nature in such contests and battles has been to rely upon bravery and the sacrifice of soldiers. This was done during the early months of the World War, when each nation lost many of its finest men because of the old sentiment that to show caution was unmanly, and because of failure to realize that human breasts can not oppose machine-guns, high explosives and poison gas. Bravery, determination and perseverance—praiseworthy as they are and reliable for ordinary procedure—crumble to ineffectiveness against the cold might of science. Thousands of graves in France and Belgium testify to this truth.

The French people have at times been belittled by the Anglo-Saxons as frivolous and effeminate, probably because the influence of the centralized power of the French court permitted the cultivation of the graces and refinements of life far beyond what prevailed at the rough and insular English court. As a matter of fact, history shows that the French people have been the most gallant in Europe and have set many an example of courageous action under fearful strain and against withering odds. An episode from medieval history illustrates this too-dauntless reliance upon the bravery of their aristocracy, rather than on the inventive talents of their middle class, and demonstrates the havoc wrought by the rising power of applied science.

In 1346, several months before the Black Death decimated the two countries, Edward the Third of England invaded France with a few thousand men. If Philip the Sixth of France had

let the English wear themselves out, no great harm would have been done; but he proudly called out his nobles and a hired force of Italian crossbow-men. At Crécy, near Abbeville, the French forced a battle, employing the familiar tactics by which the feudal knights, clad in clumsy armor, rode their war-horses in shock formation at despised footmen.

But a new factor had come into warfare. The British archers, using great yew bows and arrows a yard long (cloth-yard arrows), had learned in battles against the Scots to shoot with remarkable power and deadly precision. The Italian crossbows were powerful but cumbersome and slow. All day long the French aristocracy charged with mad valor at the stubborn foot-soldiers but were mowed down by thousands in a terrible slaughter. The improved arrows from the strong long-bows penetrated even steel armor and were more dangerous than early types of muskets. The rows of French dead demonstrated that human courage could not compete with applied mechanics. This battle marked the rise of British military influence on the Continent.

But human nature learns slowly and forgets its lessons. Ten years later, when the Black Prince invaded the south of France and could marshal only eight thousand men, the French King John surrounded him with fifty thousand at Poitiers. If the French again had merely starved the British out, there would have been no great loss. But they wished to retrieve the laurels lost at Crécy, although again the French relied upon bravery and old-fashioned tactics. With incredible folly, the French knights charged up a narrow lane where the hedges on both sides were lined with British archers, who shot them down with ease. It was a worse disaster than at Crécy. The long-bows were the machine-guns of their day, and were similarly under-estimated at first.

The French aristocracy were slow to learn the relentless danger of applied science, as represented by the force of a speeding arrow impinging on knightly armor. For generations, a fully equipped knight upon a horse had been a match for twenty untrained footmen. The French could not understand that this was no longer true. They made thicker armor, substituted plate for chain mail in a more complete covering of the body, and believed that they could rely upon dash and gallantry, not realizing that the heavier armor made the wearer more or less helpless from clumsiness, especially if he fell.

An ordinary man of to-day, though perhaps a little too tall for one of the medieval steel suits, would be liable to faint from the fatigue and heat of carrying it. The long-bow, by the way, was a Welsh invention; it was quick-firing but required unusual strength to manipulate. Many of the best archers were Welshmen. In 1414, the young English King Henry the Fifth—Shakespeare's engaging Prince Hal—landed in Normandy with fifteen thousand men. Once again the French could have cut his communications and tired the English out, but they had learned little in the two generations since Crécy. The mounted knight, pointing his long lance and charging splendidly ahead, was still their idea of war. With fifty thousand men, the French attacked Henry at Agincourt near Crécy, and the old story was repeated. The close formation of the French nobles, slipping upon wet ground, made quick movements impossible and offered easy targets for the British archers.

The battle ended in a massacre. Not until years later, when the French learned to develop the musket, did they

regain their old power in warfare. They clung to feudalism with a spirit of a better cause, just as human nature in thousands of similar cases has clung to obsolescent methods while science advanced and rewarded men ingenious enough to utilize it skilfully.

The cause of disastrous failures at many critical periods in the history of civilization has been the neglect of man to understand and use his scientific knowledge. Frequently, lesser lights in the crowd offered suggestions for improved methods and volunteered their talents but the slow-thinking officials, whom traditionalism had placed in command, often lacked the imagination to appreciate the new ideas. This procedure has been repeated time and again throughout the crises of history.

New ideas frequently have come from unconventional sources and were such disturbing factors to dignitaries in the established positions that much time was lost in adopting them. In the meantime, the original advocates of the new ideas were unrewarded and perhaps scorned for being different from their fellows. When necessity finally forced the adoption of the improved ways, the reluctant officials gradually began to think that the ideas were originally their own. Such has been the fate of many a poor inventor or gratuitous adviser who risked his future upon suggesting something new to superiors trained in the old ways. Similar procedure is not unknown in modern corporations.

Many of the advances in civilized life have been initiated by individuals of eccentric personality and disturbing views. At the beginning of their advocacy of the new ideas, their positions were usually vulnerable and perhaps their grasp of the subject imperfect. The officials who opposed them were often unintelligent men, representative of the institutions of a former day. Consequently, progress has been slow. The American philosopher William James, who was unappreciated on the faculty at Harvard until his reputation was established elsewhere, pointed out that the unorthodox but deserving thinker has a hard time at first. It should be the concern of the official leaders in a democracy to recognize and assist such struggling geniuses.

The appalling catastrophe of the Black Death, and of numerous military calamities due to inferior weapons, revealed the need for a better understanding of science. These disasters gave impetus to research and invention. Man resented his helplessness in situations where the elements turned against him. He saw the need to subdue nature by learning more about natural phenomena and the applications of science. Belatedly then the study of science was encouraged, rather than hindered. The modern world has profited enormously from this study. However, it has not yet learned how best to conduct such study, nor how to encourage the right types of scientists.

AMOS EATON (1776–1842)

SCIENTIST AND TEACHER OF SCIENCE

By Dr. H. G. GOOD

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At Williams College, from which he graduated in 1799, Amos Eaton showed particular interest in science and mathematics. He had lived on a farm in central New York and in his boyhood had acquired practical experience as a surveyor. All this was appropriate preparation for his life-work, which was the teaching of science and its applications to agriculture. Even while studying law in New York he sought out the scientists of that city, including such well-known men as David Hosack and Samuel L. Mitchill. A little later he conducted some botany classes, apparently in connection with an academy in the Catskills and was commended for taking his pupils into the field instead of teaching them from a book. After a disastrous experience as a lawyer and land speculator, and when he was already forty-one years old, he found his true vocation in science as an investigator, a text-book writer and an original and inventive teacher.

Further to prepare himself for his new career he studied at Yale College under Professors Silliman and Ives. He had access to Silliman's laboratory and to the large collection of minerals which the college had recently acquired from George Gibbs. It was Gibbs also who persuaded Silliman to establish the *American Journal of Science,* which is now in its one hundred and twenty-second year. Eli Ives was professor of botany and materia medica and a practicing physician. Eaton always cordially acknowledged his great obligations to the guidance and the life-long friendship of the Yale scientific group. In the spring of 1817 his real career began.

For several years after this period of study he carried out a series of geological surveys and gave courses of scientific lectures. His first course was delivered at Williams College and comprised lectures and field work in mineralogy, geology and botany. A contemporary witness wrote that "an uncontrollable enthusiasm for natural history took possession of every mind; and other departments of learning were, for a time, crowded out of the college." This course led immediately to Eaton's first important book, the "Manual of Botany," which, because no publisher would assume the risk, was issued "in a contracted form," 164 pages, by the students of the college. The first edition was immediately sold out and is now a very rare book. After this favorable beginning Eaton delivered many courses of scientific lectures in the towns of Massachusetts and central New York. The time was propitious. The academies were spreading and the American lyceum period was just opening. Science, when it was taught at all, was usually taught as a book subject and Eaton was among the first to study nature in the field.

Opportunity soon brought him back to his native state. Governor De Witt Clinton invited Eaton to deliver his lectures before the legislature and this brought him to the notice of Stephen Van Rensselaer. In this same year (1818) he published his "Index to the Geology of the Northern States." Van Rensselaer as a large land-owner was interested in geology as an aid to agriculture. With Van Rensselaer's support Eaton continued his geological surveys and

about 1825 he wrote: "My expenses have been defrayed for the past seven years by the Honorable Stephen Van Rensselaer who has expended more than eighteen thousand dollars during that period in causing researches and trials to be made for the purpose of improving and extending natural science."

Scientific Writings and Text-books

Eaton wrote about twenty books, large and small, and about one hundred articles and items in journals and newspapers. Many of his science items were published in the *American Journal of Science*. Several of his books were intended for his own classes. One of these was the *Chemical Instructor* (1822). This was a laboratory manual and one of the early examples of its kind in any country. Although the directions which it gives seem rather indefinite it found considerable favor in the absence of better teaching instruments. A similar purpose guided him in the preparation of his "Zoological Text-Book" (1826), which was intended "for the Rensselaer School and the popular class-room."

Eaton's first schoolbook was a translation of the Botanical Dictionary of Louis Claude Richard to which he made some additions from other authors. In the same year (1817) his "Manual of Botany" appeared. This was revised, enlarged and re-issued every two or three years until 1840 when the eighth and last edition appeared. That edition described almost 6,000 species in about 600 closely printed pages. The Manual was in the main a Flora, that is, a key to classification with locations and, in the early editions up to the fourth, with notes on "the medicinal properties of each order." Gradually also he substituted a natural system of classification for the Linnean with which he had begun. Only the last edition contained any drawings or illustrations of any kind. It was the most complete manual of its day, "the field reference book for every botanical student in the northeastern United States"; and it continued in use until it was superseded by the works of Torrey, who had received his first botanical lessons from Eaton, and by those of Asa Gray.

In geology Eaton was an explorer but an explorer of a new and particular type; and it is on this work that his scientific reputation must rest. No such detailed examinations of large areas, no such "attempt at an orderly succession of the rock strata" had ever been made in America. By comparison, the surveys of Maclure, Schoolcraft and Edwin James were mere reconnaissances. It is made a matter of reproach to Eaton that he knew no paleontology, but he had little opportunity to learn, for no one in his circle knew any more. Paleontology was a new science in the early nineteenth century; but it must be admitted that Eaton did not seize the opportunity to learn when it came to him. The second edition of the "Index to the Geology of the Northern States" came out in 1820. It was wholly "written over anew, and published under the direction of the Troy Lyceum." In the preface, with the candor which was characteristic of him, he wrote: "It is but one year since any person residing in the interior of our district has had any *practical* knowledge of Organic Relics. A fortunate incident at length presented itself. The justly celebrated Le Sueur [C. A. Lesueur, 1778–1846], the friend and companion of Cuvier, was called to Albany. . . . I availed myself of his instruction for four weeks. Though my stock of knowledge in this department of nature is still very limited, I communicated all I knew to the members of the Troy Lyceum without delay." But he did not follow up this beginning and the first steps in the study of vertebrate paleontology in the United

States were taken by others. Eaton made his report on the geology of Albany County in 1820, that on Rensselaer County in 1822 and that on the Erie Canal strip in 1824. The Geological Text-Book did not appear until 1830. In all these he included some agricultural and economic information. Perhaps his patron, Van Rensselaer, must share the blame for Eaton's failure to follow up the newest and most important lead in geology; but Eaton, also, seems to have had a somewhat narrowly practical turn of mind.

This practical tendency was shown again in an elementary work on farm mathematics called a "Prodromus" of a Practical Treatise on the Mathematical Arts (1838, 192 p.). In the preface he remarked that he had published a similar small book under the title "Art without Science" as early as 1800 and again in 1830. Professor L. C. Karpinski has informed me that the Prodromus came out in a second edition in 1848. The book was perhaps a useful manual for farmers and artisans, but it was not mathematical in the scientific sense. The contents, and the preface perhaps still more, reveal an extraordinary lack of understanding of the true nature of mathematics and of its relation to the sciences.

The scientific work of Amos Eaton was practically completed in the ten years between 1816 and 1825. His exploratory work in geology added much to the knowledge of rocks and rock strata in the northeastern United States. Even the controversies into which he was ever ready to plunge were not without their use. He was one of the founders of the American Geological Society of 1819 which had Maclure for its president and which included Gibbs, Silliman, Dana, Parker Cleaveland, Chester Dewey, Samuel L. Mitchill and other well-known figures. Historians of American geology are still debating whether Eaton should be called the "father" of their science. To botany he made few if any original contributions, but the laborious work of keeping his *Manual* up-to-date deserves generous recognition. To the other sciences upon which he wrote he contributed nothing new. He was much greater as a teacher than as an investigator and there he was great because his pupils went beyond him.

Eaton as a Teacher

What Amos Eaton had accomplished before 1825 may be regarded as a preparation for the seventeen fruitful years which followed his appointment as senior professor of the Rensselaer School. His work has sometimes been compared with that of Liebig. Both had a laboratory in which the students themselves worked with materials and instruments, but there the analogy ends. Liebig prepared investigators in one science, chemistry, and Eaton, teachers of several sciences and of the applications of those sciences to agriculture and engineering. No scientific discoveries came from Eaton's laboratories. His students, even though many of them were college graduates, were mere beginners in science. His laboratories were arranged in four rooms, one for chemistry, a natural history room for geology, mineralogy, botany and zoology, an assay room and a fourth room for natural philosophy. This was the first laboratory or chain of laboratories in America in which numbers of students could carry out experiments at the same time. In Germany and Sweden and perhaps other countries the student laboratory was being introduced for instruction in chemistry; and a still earlier analogy is found in the pharmaceutical preparation rooms connected with medical schools.

The Rensselaer School differed from those European schools in that it was

intended to prepare teachers. And it was even more original in its methods than in its equipment. An early circular describes the methods as follows:

The most distinctive character in the plan of the school consists in giving the pupil the place of the teacher in all his exercises. From schools or colleges where the highest branches are taught to the common village schools, the teacher always improves *himself* more than he does his *pupils*. Being under the necessity of relying upon his own resources and of making every subject his own, he becomes an adept as a matter of necessity. Taking advantage of this principle, students of Rensselaer School learn by giving experimental and demonstrative lectures with experiments and specimens.

In every branch of learning the student begins with its practical application, and is introduced to a knowledge of elementary principles. . . . After visiting a bleaching-factory he returns to the laboratory and produces the chlorine gas and experiments upon it until he is familiar with all the elementary principles appertaining to that curious substance. [And so with tanning and other operations.] By this method a strong desire to study an elementary principle is excited by bringing his labors to a point where he perceives the necessity of it and its direct application to a useful purpose.

One should notice in this passage the narrowly practical purpose and, secondly, the direct training in teaching by having each student experiment and then lecture and demonstrate the results to his fellow-students. Professors also lectured to classes, and books were used, but the essence of the plan was in the student lecture and demonstration. There were exercises in land surveying, in construction and engineering work, in collecting and preserving specimens in botany, zoology and mineralogy, agricultural and gardening operations and experiments. These were made "the duties of students for a stated number of hours each day." Eaton's system was, therefore, a combination of the laboratory, seminar and project methods with a constant effort to develop skill in teaching. The Rensselaer School was one of our first schools for the preparation of teachers. Its transformation into an engineering school was a later development.

How Eaton's work was regarded by an able judge of it may be seen in the estimate of one of his pupils, Professor E. N. Horsford of Harvard, who was a graduate of Rensselaer in the class of 1838. Horsford said:

It was a source of pride and satisfaction to me when, some years after my graduation, it was my fortune to enter Liebig's laboratory as a pupil, to find that the methods pursued under the guidance of that great teacher were in many respects the methods I had been familiar with in the Rensselaer Institute. . . . In a recent visit to Europe [1874] it was refreshing to see in the polytechnic education of Austria which now unquestionably has no superior in the world, the methods of the Rensselaer School of fifty years ago. It will not do to say that the methods were copied from ours, but it is proper to say that the inspiration that gave them to the eastern world moved the mind of Professor Eaton at a period as early as it did that of Pestalozzi, and Fellenberg, and Liebig, and under circumstances much less favorable.

Distinguished Early Graduates

The Rensselaer School attracted many able men as students and prepared many of them for distinguished careers in scientific investigation, teaching and popularization. The school was small in the early years, and the highest number of graduates in any one year during Eaton's headship (1825–1842) was eighteen, and the next highest, eleven. Before 1835, about one half of the graduates and one third of the non-graduates became lecturers, teachers and professors in colleges; in 1835 the school added an engineering course; and, after that, many of the graduates entered technical employments. The following table shows the occupations which attracted the largest numbers of the men who were graduated in the seventeen years of Eaton's connection with the school. Many of these followed more than one occupation in the several periods of their lives, and since each is counted only once it became

necessary to make a subjective assignment in some cases. The aim was to assign each man to the occupation in which he attained his greatest distinction. There were 166 graduates and they may be distributed as in the following:

TABLE OF OCCUPATIONS OF EARLY RENSSELAER GRADUATES

Farmers, horticulturists	20
Scientists, professors and teachers of science	24
Manufacturers of scientific instruments	3
State Superintendent of Public Instruction	1
Director (Phila.) U. S. Mint	1
Professors (Theology, Sanskrit, Chinese, English)	4
Engineers	36
Physicians	18
Manufacturers (general)	19
Merchants	14
Attorneys	12

Of the rest, five were bankers, four clergymen, three insurance agents and two dentists, making in all one hundred and sixty-six.

Names will mean more than figures in this connection, because for the advancement of science and of education, leaders are more significant than numbers. The names of some of the following Eatonian graduates, classified as geologists, agriculturists, botanists and chemists, will be familiar to the reader:

(1) Ebenezer Emmons, class of 1826, who wrote extensively on geology. He started the Taconic controversy, but it is unfair to remember him for this alone.

(2) Douglass Houghton, 1829, state geologist of Michigan, professor at the University of Michigan.

(3) Robert Peter, 1829, chemist, serving in that capacity on the state geological surveys of Kentucky, Arkansas and Indiana. Peter secured the establishment of the Kentucky Geological Survey in 1854. Contributor to medical and agricultural chemistry. Editor of a farm paper.

(4) James Hall, 1832, successively state geologist of Iowa, Wisconsin and New York, was a great leader in the study of stratigraphy and invertebrate paleontology, and in the training of young geologists.

(5) Michael Tuomey, 1835, was state geologist of South Carolina, and later of Alabama, and professor at the University of Alabama.

The five named above were geologists. The following three were even more directly influential in the development of agriculture than the geologists. They are:

(6) George Hammell Cook, 1838, succeeded Eaton in 1842 as senior professor at Rensselaer School; but his most important work was done at Rutgers. He secured the Morrill Land-Grant for that institution and organized the New Jersey Agricultural Experiment Station, of which he became the first director.

(7) Asa Fitch, 1827, became state entomologist of New York in 1854, and this has been considered the beginning of economic entomology in the United States. He published many important studies, including some on the grain insects.

(8) Ezra S. Carr, 1838, was professor of chemistry and of agriculture at the University of Wisconsin. He also held professorships at the Rush Medical College, and the University of California. He prepared the way for the establishment of the California State Agricultural Experiment Station and finally served as superintendent of public instruction in that state.

The two of Eaton's pupils who were best known as botanists were:

(9) John Leonard Riddell, 1829, wrote a "Synopsis of the Flora of the Western States" (1835), which was the pioneer work on the plants of the Ohio basin. It was prepared while he was professor of botany at the Cincinnati Medical College. He acquired a reputation as a microscopist and was the inventor, in 1851, of a binocular microscope.

(10) Abram Sager, 1831, was the first professor of botany and zoology at the University of Michigan, and founded there the Sager Herbarium. Later, he became the head of the medical school at the same institution.

The well-known chemists who received their early chemical education under Eaton were J. C. Booth, E. N. Horsford and Robert Peter. Robert Peter has been included among the geologists, and might have been counted with the agriculturists, but was primarily a chemist, and a very able one. We may cite Booth and Horsford as follows:

(11) James Curtis Booth, 1831, had studied with Hare and graduated at the University of Pennsylvania before coming to Eaton; and after

a period of teaching near New York he worked with Wöhler and Magnus in Germany. He was the first American to apply the polariscope to the analysis of sugar. He filled many exacting technical and administrative positions and was as able as a teacher as he was as chemist, technologist and scientific adviser. He may have been, I think he was, the first to establish a student laboratory for teaching chemistry in an American public high school, the Central High School of Philadelphia.

(12) Eben Norton Horsford, 1838, studied with Liebig for two years, 1844–1846, and upon his return from Europe was appointed Rumford professor and lecturer on the applications of science to the useful arts, a title that would have delighted his old master, Eaton. He organized and equipped a student laboratory of analytical chemistry in the Lawrence Scientific School at a time when the chemistry students of Harvard College were still required to memorize a text-book. He published many experimental papers in Liebig's *Annalen* and in Silliman's *Journal*. In later life he became an industrial chemist and consultant and developed a decided interest in the historical and archeological subjects.

If one had the space it would be easy to add to this list twelve or more other names of graduates who became distinguished in other, non-scientific, lines. There were a Sinologist, a lexicographer, a philologist, a medical missionary, a surgeon, several civil engineers, and others, among the one hundred and sixty-six graduates of Eaton's seventeen years at the Rensselaer School. Was it in the times, the men or the teacher that these became masters instead of underlings? Clearly all these were essential factors; and, therefore, it may not be necessary to undertake the impossible task of assessing exact values to each. Without Eaton American science education would have been less effective in that day and its history less inspiring now.

MAN IN GEOLOGICAL PERSPECTIVE

The animal species that in the past have been able to maintain their existence for more than two or three million years are relatively few in number. Most of them were comparatively simple types belonging to the less highly organized branches or phyla of the animal kingdom. Many were inhabitants of the sea where environmental conditions were remarkably stable throughout long periods of time. Among placental mammals, the major subdivision of the vertebrates to which man belongs, there is no similar record of longevity. Except under extraordinary conditions of geologic isolation, no species of placental mammal has persisted more than two or three million years. No matter how successful it may have been temporarily in multiplying and spreading over the face of the earth, each has become extinct in a geologically brief span of time. Perhaps a half million years might appropriately be taken as average "life" of a species in this group of highly organized and notably complex creatures.

But extinction does not necessarily mean failure; it has frequently indicated the acme of achievement. For example, some of the now extinct three-toed horses and four-toed camels passed on "the torch of progress" to their descendants, the one-toed horses and two-toed camels, and thus gained long-continuing security for their kind.

What, then, does the future hold for mankind? The genus *Homo* has already existed for three or four hundred thousand years; the species *Homo sapiens* has about fifty thousand years to its credit. If the average applies, we may expect nearly or quite a half million years more of existence for our kind and then either oblivion at the end of a blind alley or progressive development into some type of descendant better adjusted than we to the total environmental factors of the time.

But does the average apply? Must man exit from the scene through either of the doors—that which closed behind the dinosaurs and titanotheres or that which opened before the three-toed horses and notharctines?

Most animals tried to gain security for themselves by specializing in adjustment of structure and habit to particular environmental conditions, whereas man is a specialist in the adjustability of structures and habits to a variety of environments. No other vertebrate can live as can he, on Antarctic ice cap, in Amazonian jungle, beneath the surface of the sea or high in the air.

Furthermore, man is the world's foremost specialist in transforming environments to bring them within the range of his powers. Far more efficient than the beaver or the mound-building ant, he drains the swamp, irrigates the desert, tunnels the mountain, bridges the river, digs the canal, conditions the air in home, factory and office.—*Kirtley F. Mather, Sigma Xi Quarterly, July, 1941.*

INVASION OF A PROTECTED AREA BY EXOTIC PLANTS

By Dr. RICHARD M. BOND and ATWELL M. WALLACE
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PROFESSOR H. C. HANSON[1] stresses the value of areas that have never been cultivated or grazed, as checks with which to compare the effects of land use as practiced on surrounding lands.

During the course of a survey recently conducted by the Soil Conservation Service on the Pyramid Lake Indian Reservation, Nevada, such an "untouched" check area was examined and some interesting conditions were found.

The "check area" in question is Anaho Island in Pyramid Lake (See map, Fig. 1), an island of volcanic origin about 450 feet high. The elevation of the highest point is given as 4,360 feet on the U. S. Geological Survey, Reno quadrangle. Nearly all the rock outcrops are covered with several inches of calcareous tufa laid down by algae when the lake level was higher than it has been in historic times. The area of the whole island is approximately 260 acres. This may be divided into an upper section, of about 75 acres and a lower section of about 185 acres.

In the past there were two levels at which the water in Pyramid Lake stood long enough or often enough to form clearly marked beach lines. The lower of these marks the level of overflow from Pyramid Lake into Winnemucca Lake, and the other, a few feet higher, marks the overflow level of Winnemucca Lake into the Mud Lake Desert. On Anaho Island this upper beach line is best marked, and is considered as the demarkation between the upper and lower sections of the island. The upper section has long been out of water, and there has been some weathering and soil formation on it. The lower part of the island shows almost no weathering; plant growth on this section dates only from about 1906, since which time the lake has fallen fairly steadily a distance of about 75 feet.

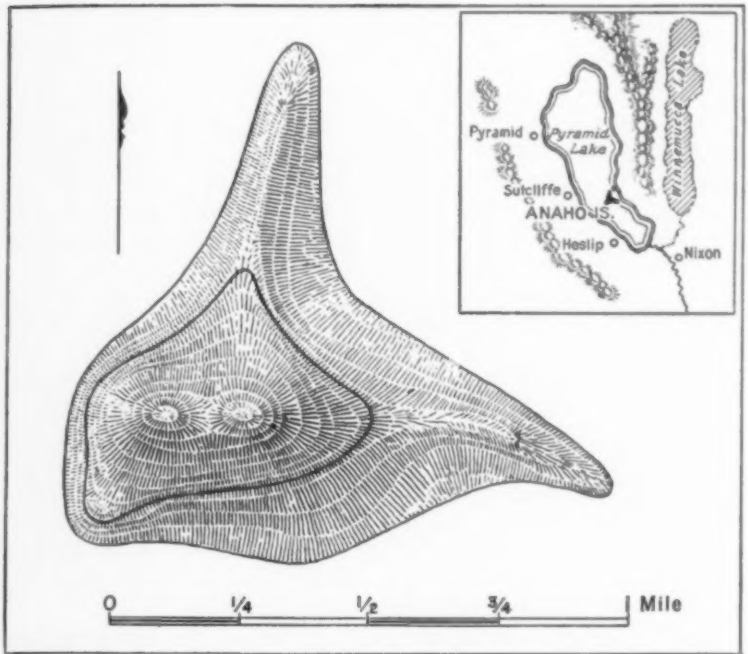
The vegetation of Anaho Island is generally characteristic of the lower, arid part of the Upper Sonoran Life Zone. There appears to be no zonal differentiation between the top and the base of the island. The reptiles are mostly Lower Sonoran, the birds are not zonally restricted, and the mammals have not been investigated.

As might be expected, the vegetation of the upper section of the island serves well as a check on the grazing use of the neighboring mainland. The main difference noted was that the perennial grasses *Stipa speciosa* and to a lesser extent *Poa* sp. were much more abundant and luxuriant than at comparable elevations on the mainland. It appears that grazing on the mainland has eliminated these grasses from the lowlands; they are still common in better watered areas, 1,000 feet or more above the lake.

The vegetation of the lower section of the island, where soil formation can scarcely be said to have begun, though characteristic of the same life zone, is very different and is limited to relatively few species. Probably less than one third of the sparse plant cover is native, consisting mainly of *Atriplex canescens*, *A. confertifolia*, *Sarcobatus vermiculatus* and *Distichlis stricta*.

The rest of the plant cover of the lower section of the island consists of exot-

[1] H. C. Hanson, THE SCIENTIFIC MONTHLY, 48: 130–146, 1939.



SKETCH MAP OF ANAHO ISLAND, PYRAMID LAKE, NEVADA

ics, mainly *Bassia hyssopifolia,* and the grasses *Bromus tectorum* and *B. rubens;* there is also a good deal of *Salsola kali* var. *tenuifolia.* That part of the lower section lying above the level of overflow into Winnemucca Lake has, in many places, also a good stand of *Erodium cicutarium,* probably because soil formation has progressed a little further here.

The exotic grasses and the *Erodium* have penetrated into many parts of the upper section of the island also. There they give the impression of having filled a vacant niche, without seriously competing with the native vegetation or disturbing it.

The following plant species are found on Anaho Island, Pyramid Lake. In the upper section of the island are found *Poa* sp., *Stipa speciosa* Trin. and Rupr., *Grayia spinosa* (Hook.) Moq., *Eurotia lanata* (Pursh) Moq. and *Sarcobatus baileyi* Cov. In the lower part of the island there are *Distichlis stricta* (Torr.) Rydb., *Sarcobatus vermiculatus* (Hook.) Torr., *Bassia hyssopifolia* (Pall.) Kuntze, *Salsola kali* L. var. *tenuifolia* G. F. W. Mey, *Mentzelia albicaulis* Dougl. and *Oenothera caespitosa* Nutt. The species found on both the upper and lower sections include *Bromus tectorium* L., *B. rubens* L., *Sitanion hystrix* (Nutt.) J. G. Smith, *Oryzopsis hymenoides* (Roem. and Schult.) Ricker, *Atriplex confertifolia* (Torr. and Frem.) Wats., *Atriplex canescens* (Pursh) Nutt., *Erodium cicutarium* L'Her., *Lygodesmia spinosa* Nutt. and *Artemisia spinescens* Eat. This list contains only the species that were common or conspicuous in June, 1940. Many early-blooming, rare and inconspicuous species were undoubtedly overlooked.

Two subjects for speculation arise with respect to the vegetation of Anaho Island: 1. How did the exotic plants reach it in the first place? 2. How do they manage to survive there in competition with the native vegetation?

The answer to the first question is not very far to seek. Seed may have arrived by any or all of three methods from the mainland where all the species are common. They may have been carried by birds, carried by the wind or floated across on the water. The last seems most probable. Whether the seeds reached the island by wind or water, it is quite likely that the birds have aided in their local distribution.

The answer to the second question is more difficult. It would at first sight appear that suitable native primary weed species would be present, and at least as capable as the exotics of starting the plant succession. This seems likely because Anaho Island is a breeding ground for several thousand white pelicans (*Pelecanus erythrorhynchos* Gmelin),[2, 3] which nest on the ground in dense colonies. They disturb the soil, and much of the vegetation is killed either by being trampled or through "burning" by the excrement of the birds. Since this disturbance caused by the pelicans has been going on for hundreds if not thousands of years, and since the colonies are often moved from year to year, it would appear that conditions on parts of the island should have been ideal for the continued existence of a stock of pioneer native plant species which would have invaded the lower section of the island as it was uncovered by the receding water. This, however, does not appear to have happened. Nesting sites deserted for two or three years were found to support little but *Atriplex confertifolia* and the two species of *Bromus*. The following alternatives suggest themselves as possible explanations for these conditions:

1. The pelicans did not disturb the upper part of the island enough to encourage pioneer growth. By the time the lower part of the island was uncovered, exotics had largely displaced natives on the mainland through grazing and overgrazing, and these provided the only source of seed of suitable plants for the lower section of the island.

2. The exotic plants are more aggressive and have displaced the native species in competition.

3. The exotic species are intrinsically lower in the scale of succession than any available native plants. Perhaps they will in time be succeeded by natives when they have sufficiently affected the environment.

We wish to express our thanks to the personnel of the Vegetative Type Map Herbarium of the California Forest and Range Experiment Station, and to Dr. H. L. Mason, of the University of California Herbarium, for help in plant identification.

[2] E. R. Hall, *Condor*, 27: 147–160, 1925.

[3] R. M. Bond, *Condor*, 42(5): 246–250, 1940.

BOOKS ON SCIENCE FOR LAYMEN

INSTINCT AND ANIMAL BEHAVIOR[1]

In all accounts of the activities of animals, the great stumbling block on which explanations and theories either crash or build is that section of our ignorance which we hide under the term "instinct." Therefore, any attempt to examine animal behavior that does not involve instinct is like a ray of hope, no matter how uniformly disappointing such rays have been in the past. It may be said at the outset that the present book is one more addition to the long list of disappointments. The author states his aim is, ". . . to investigate the animal world and to study animals as creatures which feel and act as individuals. We shall see that all theories of mysterious mechanism, by which organisms are set in motion like machines, will disappear. Both animals and human beings will be seen to act according to one and the same fundamental principle—a psychological stimulus leads to a search for the *means* and activates the *will* to satisfy it."

When we come to read the body of the book, we are forced to the conclusion that what the author has been fighting against is not the usual conception of instinct, but a very naive one of instinct as a suddenly appearing, mysterious, almost unimaginable driving and guiding force. Against this generally discarded notion, he builds up a series of "impulses" and even titles the four sections of the book —Impulses of Self Preservation, Impulses Leading to Propagation, Social Impulses and Impulses of Migration. However, his "impulses" are very hard to distinguish from what most of us call "instincts." He attempts to differentiate the two by stating that an impulse ". . . has nothing whatever to do with the idea of instinct. An impulse is not an established characteristic, but only a temporary biological expression for a psychological sensation to be determined later." The usual concept of instinctive behavior involves stimuli for its expression in any given instance. Thus, instincts of self-preservation are not manifest except when needed, *i.e.*, when some stimulus calls them into operation. Possibly "impulse," as a word, may be thought an improvement over "instinct," but as a concept, it is about the same. In the section of the book dealing with impulses of migration, the author's case becomes very weak. Indeed, all through the work, one finds evidences of too much "arm chair" natural history, some of it wrong, some of it over-simplified for convenient pigeon-holing. Much of it is acceptable, but is not infrequently marred by evidences of the author's unfamiliarity with the material, although this may, to some extent, be due to poor translation from the original German manuscript.

The book is illustrated by a good number (41) of black and white ink drawings by Erna Pinner and has a short, explanatory and rather cautious foreword by L. J. F. Brimble.

Herbert Friedmann

[1] *Animal Behavior.* J. A. Loeser. x + 178 pp. $2.00. 1940. Macmillan Company.

PSYCHIATRY AND THE SOCIAL WORKER[1]

A great amount of time and study have gone into the preparation and writing of this book—an expenditure of effort which has been going on for ten years or more in the American Association of Psychiatric Social Workers in an effort to define their field and function—and one is left with the feeling that these still are not defined, though the book does

[1] *Psychiatric Social Work.* L. M. French. xvi + 344 pp. $2.25. 1940. Commonwealth Fund.

point up the trends within the entire field and the problems of definition.

A picture is revealed of the origin and development of psychiatric social work and of the A.A.P.S.W. as a specialized group with a professional function in the beginning but with this professional function becoming increasingly obscure as psychiatric knowledge, skills and techniques became more and more a part of social case work in general and of the professional training for all case work. It describes how members of the association went into all fields of work—first as consultants or as educators in mental hygiene—later as regular members of the case work staffs until since 1937 about 50 per cent. of the membership are so employed (about 25 per cent. in the family welfare field) and only about 50 per cent. remain in the hospital and clinic field with a marked tendency for association members and graduates of professional schools to reject this field for the other fields of case work.

All interpretation in the book is based upon the thesis that psychiatric social work is social work practiced in connection with psychiatry. It is, therefore, not an expression of the opinion of the association as a whole. It is the opinion of one group—the study having been made and the book written by early members of the association. The statistical study which covered number of workers, types of agencies represented, turnover among workers, professional equipment, salaries and opportunities for placement gave no opportunity for differences of opinion to be tabulated.

Interpretation often implies considerable question about the development of specialized skills that have developed and are continuing to develop particularly within the family and child welfare fields because these are not being practiced in connection with psychiatry (mention is made that psychiatrists or analysts may be on the staff of the agency but this does not make it psychiatric social work). This feeling is not shared by the entire association.

That the book brings into focus important problems for the association is certain; that it has contributed to clarification of a definition of psychiatric social work is doubtful. With as general acceptance as there has been of the psychiatric social worker doing what has been considered psychiatric social work in a variety of agencies for a period of more than ten years, can the association (or a part of it) now say this is not psychiatric social work and make it so? On the other hand the association, which has been losing its identity, may need to renew its life, under this or another name, by defining its functions and activities in relation to psychiatry in the hospitals and clinics and thereby maintain a specialized service within the case work field.

DOROTHY THOMAS

FACT AND FANCY IN GENETICS[1]

THIS new text-book begins with a chapter of historical matter, "The Rise of Genetics," well illustrated and fuller than is to be found in other texts currently in use. This favorable beginning is completely belied by the sequel. Chapter II deals with "The Laws of Mendel," commencing with a complete dose of genetic terminology defined in a way neither Mendel nor any other geneticist would comprehend. Samples: "The offspring of an experimental cross are *hybrids*. Breeding a hybrid to a brother or sister type is *inbreeding*." "If the hybrids in any generation resemble each other in all somatic characters, they are *phenotypes*. Phenotypes known to have identical factors in the

[1] *Principles of Genetics*. E. Grace White. 430 pp. $2.50. 1940. C. V. Mosby Company.

genes are *genotypes*." Passing on to the discussion of the effect of external conditions upon character expression, we are surprised to learn that Himalayan rabbits from which patches of white and black fur are removed and which are then kept in a cold place will grow black fur where there was formerly white, and white fur where there was previously black (p. 46). Passing by numerous other inaccuracies and inadequacies of expression, we find, in Chapter III, "The Cytologic Basis," figures of mitosis from the author's previous "Text-book of General Biology" that show chromatids at metaphase quite unoriented and chromosomes at late telophase still completely condensed, while the accompanying discussion describes a single spireme thread in prophase. As to chromosome number, "a change in chromosome number constitutes a species change" (p. 64). The section on "Meiosis" begins with the ambiguous sentence: "The meiotic phase may occur at three different periods in the life cycle; consequently, there are three different types or organisms" and leads us on to "threads (that) come to lie side by side in pairs which unite forming a thicker thread called the *pachytene*" (p. 68). Later "the chromatids move apart in pairs as they shorten and thicken, and assume shapes . . . (that) are believed to be caused by an interchange between sections of sister chromatids, and are called *chiasmata*" (p. 69). These misleading statements are characteristic of the author's style throughout.

The reviewer was unable to advance any farther in this hodge-podge of ill-mixed fact and fancy. To imagine its effect upon an unsuspecting student would be enough to drive most teachers of genetics to frenzy.

H. Bentley Glass

THE TELEPHONE IN A CHANGING WORLD[1]

In the foreword by Marion Dilts to her most recent book, "The Telephone in a Changing World," there is a minor point of veracity. After explaining her inspiration in remarks by Sir Richard Gregory, she says that those with whom she discussed the idea were encouraging. The present reviewer at that time was even discouraging. He was appalled by the magnitude of the task which the young lady proposed: a Baconian survey of an industry three times her own age. In spite of the discouraging advice, she went ahead and completed her task.

The result is beguilingly readable although encyclopedic in range. It is not a source book but amazing in the variety and coverage of its sources. Not always would this reviewer have selected for emphasis the same items, scientific, social or economic. Selection and emphasis, however, are an author's privilege; and with the picture which results there can be no serious quarrel. The publishers would probably be safe to advertise the book on a money-back guarantee to purchasers who are not struck by at least ten pertinent facts outside their previous knowledge of the telephone. ¶On glancing through the book again I'll raise the publisher's ante to 20.

John Mills

[1] *The Telephone in a Changing World.* M. M. Dilts. Illustrated. xiv + 219 pp. $2.50. April, 1941. Longmans, Green and Company.

THE PRESENTATION OF THE THEOBALD SMITH AWARD

DR. IRVING LANGMUIR, PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, WITH THE RECIPIENT DR. HERALD R. COX, PRINCIPAL BACTERIOLOGIST IN THE UNITED STATES PUBLIC HEALTH SERVICE.

THE PROGRESS OF SCIENCE

THE THEOBALD SMITH AWARD TO DR. HERALD R. COX

THE American Association for the Advancement of Science has two annual prizes. The first of these is the Thousand Dollar Prize for a paper of outstanding importance presented at each annual meeting. This prize was established by an anonymous friend of the association and has been awarded each year since 1923. The second prize is one thousand dollars and a bronze medal awarded at summer meetings for a distinguished contribution to medical science by a person under thirty-five years of age. The fourth award of this prize, which was established by the Eli Lilly Company, was conferred on Dr. Herald R. Cox at the meeting of the association which was held at the University of Chicago, from September 22 to September 27.

Dr. Cox received the Theobald Smith Award for his development of methods of producing vaccines for Rocky Mountain fever and related severe maladies known as rickettsial diseases, the causative agents of which are viruses. These diseases are called rickettsial by specialists in the field, in memory of Dr. Howard Ricketts, who first established the cause of Rocky Mountain spotted fever. At the time of the discovery Dr. Ricketts was a rising young scientist in the University of Chicago, for whom a bright future was predicted by all his older colleagues. But these predictions were not to be fulfilled because he lost his life from an accidental infection while he was studying the disease in Mexico City in 1910. With his death medical science added another bright name to its long list of martyrs who have made the supreme sacrifice in response to the simple call of duty.

At the Chicago meeting, Dr. Cox delivered a lecture before the Section on Medical Sciences on "Cultivation of Rickettsiae of Rocky Mountain Spotted Fever, Typhus and Q Fever Groups in the Embryonic Tissues of Developing Chicks." Although the low forms of life that produce these dreaded diseases can not be cultivated successfully in the usual culture media, Dr. Cox found that they can be grown in the fertilized embryos of the eggs of hens. His results are not only of scientific interest, but they are of the highest practical value because they can be used for producing curative vaccines in large quantities and at relatively low cost. It is fortunate that Dr. Cox has perfected his production methods at the present time because the Dakotas and neighboring regions have been suffering from the severest known epidemic of sleeping sickness, one of the diseases belonging to the rickettsiae group. In fact, the situation was so serious that Dr. Cox hastened back to his work in the Rocky Mountain Laboratory of the U. S. Public Health Service, Hamilton, Montana, cutting short a visit to his former home in Rosedale, Indiana.

There are several interesting aspects of the award to Dr. Cox and of the work for which it has been given. Foremost is the fact that he perfected his methods just before a severe epidemic of a rickettsial disease. Then, it must be encouraging to every student in medical science to learn that a young man only thirty-four years of age has been able to make such a distinguished contribution to human welfare and that his work has been so conspicuously honored. It is encouraging that such a prize as the Theobald Smith Award has been established, for it honors the memory of a great scientist and rewards those who follow successfully in his footsteps. Finally, it is

inspiring to all of us that from such villages as Rosedale young men emerge with the self-reliance, industry, intellectual integrity and persevering ability necessary to achieve distinction in the morning of life, for these are the men in whose hands the future of our civilization rests.

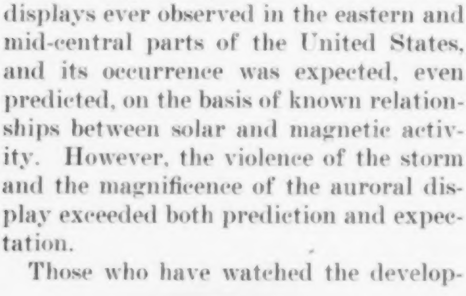
F. R. MOULTON

THE GREAT GEOMAGNETIC STORM OF SEPTEMBER 18–19, 1941

NEARLY matching in violence the great geomagnetic storm of Easter Sunday, March 24, 1940, the second greatest geomagnetic storm of the present cycle of solar and geomagnetic activity occurred on September 18, 1941. When the records have been completely reduced these two storms, together with several others of unusual violence, will probably mark the current cycle as the most active in the annals of geomagnetism.

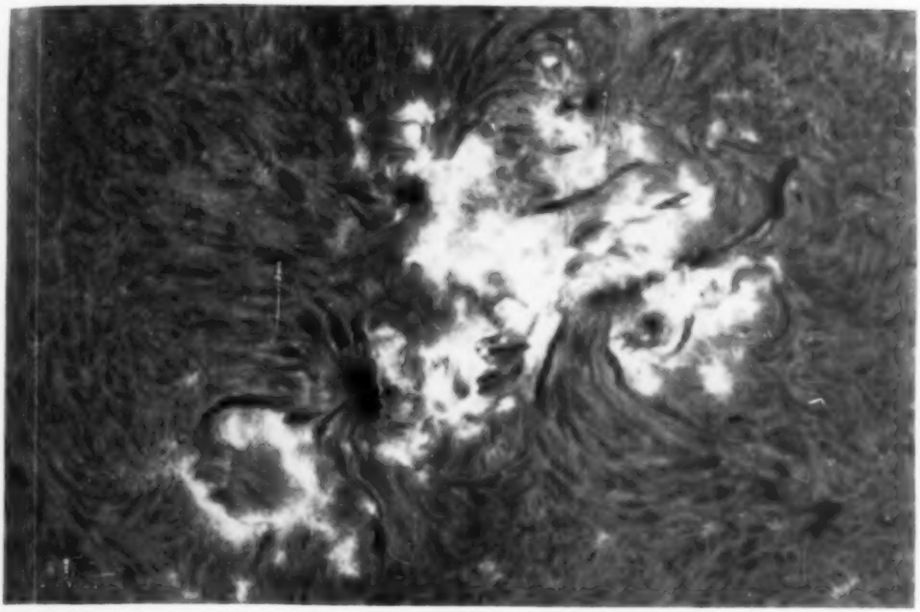
The recent storm was noteworthy for two reasons—it was accompanied by one of the most prolonged and intense auroral displays ever observed in the eastern and mid-central parts of the United States, and its occurrence was expected, even predicted, on the basis of known relationships between solar and magnetic activity. However, the violence of the storm and the magnificence of the auroral display exceeded both prediction and expectation.

Those who have watched the development of sunspots in relation to geomagnetic activity recognize that, while no direct and infallible relationships between solar and geomagnetic activity have yet been discerned, large and rapidly changing sunspot-groups are most frequently associated with geomagnetic storms, and that the efficiency of these spot-groups in producing terrestrial effects appears to attain its maximum when the groups are in low heliographic latitudes and passing the central meridian of the sun. H. W. Wells, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, has closely followed the daily reports of areas, numbers and locations of sunspot-groups supplied to the Department by the United States Naval Observatory. Several days before the occurrence of the recent geomagnetic storm he formally warned that radio people should be watchful for disturbed geomagnetic and ionospheric conditions beginning about September 18. The importance of this warning has been well demonstrated by what followed.



THE GROUP OF SUNSPOTS
NEARLY 100,000 MILES IN DIAMETER, PHOTOGRAPHED IN NORMAL LIGHT ON SEPTEMBER 15 BY THE MOUNT WILSON OBSERVATORY.

For several days the earth's magnetic field had been slightly disturbed. At 11 P.M., EST, September 17, violent fluctuations in the direction and intensity of the earth's magnetism began, increasing in severity for the next few hours, attaining a maximum of activity, according to the magnetic records, between 1 P.M. and 3 P.M., September 18. During this interval —more precisely from 2:45 P.M. to 2:50 P.M.—vibrations in electrical power transformers at Takoma Park (Maryland) and at Safe Harbor (Pennsylvania) were noted and a variation of one per cent. in voltage was recorded. These



THE GREAT SUNSPOT GROUP
PHOTOGRAPHED WITH LIGHT FROM OVERLYING CLOUDS OF LUMINOUS CALCIUM VAPOR, SEPTEMBER 16, 6:36 A.M., PACIFIC STANDARD TIME.

transformers are at the termini of a 230-kilovolt interconnecting line extending approximately 100 miles from Washington, D. C., to Safe Harbor, Pennsylvania. Meanwhile extensive interference with long-distance radio, telegraphic and telephonic communications was being experienced.

But nature had scheduled her choice act for the evening hours. Those who watched the evening sun go down were aware of a strangely persistent glow in the northwestern sky. As the sky darkened, distinct rays were visible in the northern sky, brightening, fading and continually changing. By 8 P.M. the entire sky was filled with rays apparently converging to a point near the zenith to produce a vivid coronal formation. Various forms of auroral activity, rays, curtains, extensive arcs and flickering rays resembling search-light or air-beacon beams continued until almost dawn September 19. Some auroral activity was noted during the preceding and following nights, neither being comparable with the display of September 18–19.

The coronal display was visible simultaneously in widely separated parts of the country. To all observers everywhere the rays seemed to converge toward a point slightly south of the zenith. Actually, of course, there was no convergence. The particles shot off from the sun, being electrically charged, can not freely cross the earth's magnetic field and must travel in the direction of the magnetic lines of force. At Washington the lines of force are tilted about 20° southward from the vertical while further north the tilt is less. Thus all observers were viewing a bundle of closely parallel rays, extending tens or hundreds of miles upward in the rarefied atmosphere, and appearing to converge toward what is called the magnetic zenith just as railroad tracks appear to converge toward a point on the horizon.

At the time of the most outstanding part of the display vibrations in electric-

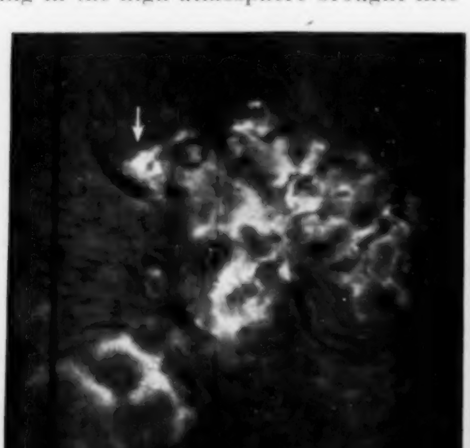
power transformers were again noted and voltage fluctuations of two and one half per cent. were recorded in Baltimore. According to a report of R. N. Weaver, chief operator of the Safe Harbor Water Power Corporation, one of the operators, R. S. Mellinger, observed that vibrations in a transformer "could be very definitely tied in with the aurora-borealis display, in that the vibrations would build up in intensity with the build-up of brilliancy of the lights."

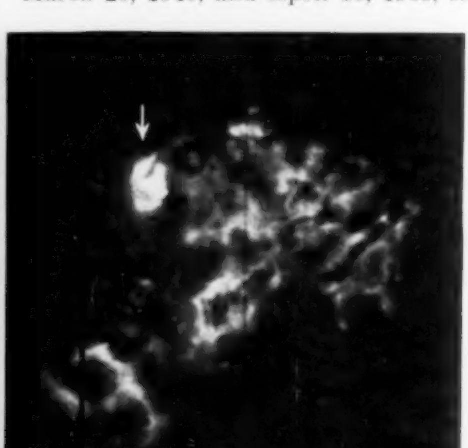
The immediate cause of the effects on electric-power systems and wired communication lines is well understood by scientists. Rapid changes in the earth's magnetism occurring during the storm induce electric currents in the conducting substance of the earth (of which the power- and communication-lines are a part) in very much the same manner as electric currents are generated in the armature of a dynamo. These currents overload the lines and produce the effects noted.

The magnetic changes in turn are produced by intense electric currents—amounting to millions of amperes—flowing in the high atmosphere brought into existence in some as yet unexplained way by the influx of solar particles which produce the auroral effects. Thus when one gazes at an apparently quiescent auroral arc he should realize that the luminous belt he sees is in reality the path of an exceedingly intense electric current.

Disturbances of radio communication associated with geomagnetic storms are also explained by the high atmospheric effects of the storm. Radio communication over long distances depends upon reflection of the radio waves by relatively sharply defined strata in the high atmosphere. Bombardment of these high regions by solar particles disturbs the homogeneity of the layers with resultant scattering and absorption of the radio waves.

Some curiosity may arise over the fact that this very exceptional storm occurred considerably after the passage of the maximum of the present sunspot-cycle which may be taken as in 1937. This is not remarkable to those familiar with the facts of solar-terrestrial relationships—all the three great storms of the present cycle, those of September 18–19, 1941, March 20, 1940, and April 16, 1938, oc-





BRIGHT CHROMOSPHERE ERUPTIONS IN SUNSPOT GROUP

PHOTOGRAPHED IN THE LIGHT OF LUMINOUS HYDROGEN VAPOR. *Left:* THE BRIGHT ERUPTION STARTING, TAKEN ON SEPTEMBER 17, 6:26 A.M., PACIFIC STANDARD TIME. *Right:* THE ERUPTION, GREATLY INCREASED IN BRIGHTNESS, TEN MINUTES LATER.

TABLE 1

GREAT MAGNETIC STORMS[1]

Date	Ranges[2] Declination	Horizontal intensity	Vertical intensity	Station	Remarks
	′	γ	γ		
1859, Aug. 28–Sept. 7	140	700(?)	400(?)	Greenwich, England	
1872, Feb. 4	...	> 960	...	Bombay, India	Aurora seen at Bombay
1882, Nov. 17–21 ...	115	>1090	>1060	Greenwich, England	Largest sunspot-group of that cycle on sun
1903, Oct. 31–Nov. 1.	186	> 950	> 950	Potsdam, Germany	
1909, Sept. 25	210	>1500	>1100	Potsdam, Germany	Lasted only about 10 hours
	68	800	235	San Juan, Puerto Rico	
1921, May 13–16 ...	199	1060	1100	Potsdam, Germany	Aurora seen at Samoa
	>120	> 800	>1000	Cheltenham, Maryland	
	96	>1100	453	Watheroo, Western Australia	
1938, Apr. 16	320	1900	600	Potsdam, Germany	Lasted only about 10 hours
	25	1320	118	Huancayo, Peru	
	291	1120	1020	Cheltenham, Maryland	
1940, Mar. 24–25 ...	135	2300	900	Potsdam, Germany	Severe disturbance of power-circuits in North America
	137	850	1100	Cheltenham, Maryland	
	21	1390	122	Huancayo, Peru	
1941, Sept. 18–19 ...	264	2544	1390	Cheltenham, Maryland	Remarkable auroral display in eastern and mid-central parts of United States
	71	684	...	Watheroo, Western Australia	

[1] Expressed in minutes of arc for declination and in γ ($1\gamma = 0.00001$ gauss) for horizontal and vertical components.

[2] Table 1 is an extension of one appearing in "Geomagnetism" by S. Chapman and J. Bartels.

curred after the sunspot-maximum. The great storm of May, 1921, occurred four years after the maximum in 1917 and the one of 1909 about three years after the maximum.

The accepted explanation of this apparent anomaly is that during the ascending part of the cycle the sunspots are in high heliographic latitudes from which radially directed streams of solar particles are less likely to reach the earth than they are if proceeding from lower heliographic latitudes where the sunspots are during the descending part of the cycle. Another fact—that more and greater storms occur around the equinoxes—finds a related explanation. Owing to the obliquity of the solar rotational axis with respect to the plane of the ecliptic, the earth is above different heliographic latitudes at different times of the year. On September 7 and March 5 the earth attains its northernmost and southernmost heliographic positions and therefore is most nearly in a line with the center of the sun and the active zone on the sun's surface, so that radial streams of solar particles are most likely to encounter the earth at this time.

Thus when a sunspot-group crosses the solar meridian around the equinoxes during the descending part of the sunspot-cycle the earth is in the most favorable position to encounter a stream of solar particles. If that group is large and exhibits unusual activity at that critical time something is likely to happen. Happen it did in the present case and millions of Americans, even in the southern parts of the United States, witnessed one of the most magnificent auroral displays of recent times.

A. G. McNish

THE WEATHER BUREAU—FIFTY YEARS OF PROGRESS

On June 30 of this year the Weather Bureau completed its 50th year as a civilian service. Its establishment in 1891 as a Bureau of the Department of Agriculture did not, however, represent its real beginning, as is shown in the following historical summary based on the Proceedings of the American Society of Civil Engineers for January, 1933.

Josiah Meigs, Commissioner of the United States General Land Office, established tri-daily observations at all Land Offices in 1817, this being the first attempt on the part of the Federal Government to make systematic observations on climatological phenomena. In the following year, the Surgeon-General of the Army issued an order requiring all surgeons in Army hospitals to keep observations on the weather. In 1825, the State of New York and, in 1837, the State of Pennsylvania, initiated statewide collection of weather data. In 1841, the United States Patent Office commenced the collection of such data upon a broader scope and, in 1847, the Smithsonian Institution inaugurated a system of organized observations. The first published weather forecast based upon simultaneous telegraphic observations was inaugurated in 1849 by Professor Henry, of the Smithsonian Institution, and these forecasts were continued until 1861.

The plans for the present Weather Bureau were originated in part by Professor Abbe, director of the Mitchell Astronomical Observatory, at Cincinnati, during the period, 1868–70.

A bill based on these plans was passed by Congress in 1870 and provided:

for the taking of meteorological observations at military stations in the interior of the continent and at other points in states and territories of the United States, and for giving notice on the northern lakes and at the sea coast, by magnetic telegraph and marine signals, of the approach and force of storms.

Under this act the service was begun as reported by the Chief Signal Officer in his Report to the Secretary of War for the fiscal year 1871:

On November 1, 1870, at 7:35 A.M., the first systematized synchronous meteoric reports ever

THE OLD WEATHER BUREAU BUILDING COMPLETED IN 1886

ITS INTERIOR DECORATIONS INDICATE THAT THE BUILDING MAY HAVE BEEN INTENDED FOR USE AS A CENTRAL AMERICAN EMBASSY. IT WAS ACQUIRED BY THE WAR DEPARTMENT IN 1888 AND FIRST OCCUPIED IN THE SAME YEAR BY THE METEOROLOGICAL SERVICE OF THE SIGNAL CORPS, THEN UNDER THE DIRECTION OF GENERAL A. W. GREELY.

ARCHITECT'S DRAWING OF THE PROPOSED ADMINISTRATION BUILDING OF THE U. S. WEATHER BUREAU. THE RIGHT-HAND THIRD OF THE BUILDING WAS COMPLETED AND OCCUPIED IN MAY OF THIS YEAR.

taken in the United States were read from the instruments by the observer-sergeant of the signal service at twenty-four stations, and placed upon the telegraphic wires for transmission.

With the delivery of these reports at Washington, and at the other cities and ports to which it has been arranged they should be sent, which delivery was made by 9 A.M., commenced the practical working of this division of the signal service in this country.

With this beginning, the national meteorological service continued to function as a unit of the Army Signal Corps until its transfer to the Department of Agriculture on July 1, 1891, where it remained for 49 years, lacking one day. By Presidential Reorganization Order No. IV, it was transferred to the Department of Commerce on June 30, 1940.

From the 24 stations mentioned in the Chief Signal Officer's report quoted above, the field network of observing and reporting stations under the Weather Bureau's supervision has grown to 800. Forecasting centers, beginning with the original one at Washington, now number fourteen, including those in Alaska, the Hawaiian Islands and Puerto Rico. Special demands, not fully satisfied by the general forecasts, have required the establishment of certain special services—the Hurricane Warning service, the Aviation Weather service, the Fire-Weather service, the River and Flood service, the Fruit-frost service, the Winter Sports service—whose functions are implied by their service names. Forecasts, warnings and current information are conveyed to the public through the facilities of 600 radio stations, a mailing list of 25,000 daily maps and bulletins, automatic telephone announcements, storm warning displays, nation-wide teletype distribution and direct telephone and telegraphic report. The nation-wide observing organization includes upwards of 5,000 unpaid observers for the collection of climatological data in addition to a somewhat larger number for furnishing the specialized observations required in the special services mentioned above, and from ships at sea.

Besides the continuous round-the-clock operation of its various forecasting services and their innumerable applications to public life, the Climatological Service of the Weather Bureau has also an honorable though less generally conspicuous history. It is the business of this division to keep the weather records—to receive

FIRST UNIT OF THE NEW WEATHER BUREAU ADMINISTRATION BUILDING
ERECTED DURING 1940–41 ON THE GROUND DIRECTLY IN FRONT OF THE OLD BUILDING. BOTH BUILDINGS, THOUGH FULLY OCCUPIED, ARE STILL INSUFFICIENT TO HOUSE THE WASHINGTON STAFF. THE RADIOSONDE LABORATORY, THE INSTRUMENT AND PROCUREMENT SECTIONS, AND ONE RESEARCH UNIT OCCUPY RENTED SPACE IN OTHER OFFICE BUILDINGS NEARBY.

all observations after their immediate purpose has been served, to record systematically and to publish the measurements of temperature, rain, frosts, winds and other meteorological elements that make up one of the most complex national climates on earth. Although the value of these data will be obvious with respect to agriculture, manufacture, the public health, aviation and some other easily definable large-scale activities, their ultimate usefulness is literally beyond measure. In the 50 years of the Weather Bureau's civilian status the network of climatological observing points has been increased from approximately 2,000 to over 5,000 stations and extended to Alaska, the Hawaiian Islands and the Caribbean; and no single unit of the Weather Bureau has contributed more significantly to the program of the national defense than has this one with its reliable long-term statistics upon the weather characteristics of the United States and its possessions.

Accompanying the growth and supporting the purpose of the direct services, the theoretical researches of Weather Bureau meteorologists have contributed continuously to the knowledge and value of the science. The problem confronting the earlier investigators was essentially to discover from surface weather observations the complex secrets of an active atmosphere many miles in depth, in a state of ceaseless motion, and to a very large extent unsusceptible of direct observation. Even with this handicap, William Ferrel was able to produce his "Meteorological Researches" and other writings, and Humphreys his "Physics of the Air," to mention but two of the more notable examples. In addition to these, the *Bulletin of the Mount Weather Observatory* and the long series of the *Monthly Weather Review* are rich in contributions of lasting value to the science of meteorology.

From the modern scientific standpoint, developments in meteorology must be attributed in large part to the invention and refinement of methods for observing the conditions and actions of the upper levels of the atmosphere. Directions and

velocities of winds, systematically observed and plotted in the pilot balloon program begun in 1918, represent an important portion of this work; and more recently the development of the radiosonde has placed within reach invaluable data upon upper-level pressures, temperatures and humidities. The need and importance of this kind of information have of course always been apparent to meteorologists, and long before either airplane or radiosonde observations were possible, the Weather Bureau began gathering upper-air records by means of kites and occasional sounding balloon flights. These methods were displaced during the early 30's by airplane observations, made with instruments carried aloft at specified times and places. Although better than the earlier observations, these too were deficient, not only in number but also because flights frequently could not be risked during critical storm conditions. More recently, with its improvement as a meteorological measuring device, the radiosonde has displaced the airplane as a means for gathering upper air data. There are now in operation in the United States and possessions some 50 radiosonde stations taking observations twice a day.

The usefulness of these observations has already been clearly reflected in forecasts with more accurate timing and more complete description of weather behavior. In addition, the upper-air data have supplemented and clarified many of the working principles of the Air Mass and Frontal system of weather analysis and forecasting as it applies in the United States, and seem to offer good promise of a reliable extension of the time-period of forecasts. The fundamental ideas of the Air Mass method, known to meteorologists for well over a century, were first effectively developed and applied by J. Bjerknes, of the Norwegian Meteorological Service, during the first world war. That this system provides a far more systematic method for interpreting and predicting atmospheric actions than those previously used is in large part owing to the fact that it evaluates the significance not merely of surface observations but also of those taken throughout the vertical depth of the active atmosphere. There seems ample reason to believe that the use of this method, combined with continued analysis of the data upon which it primarily depends, will produce yet greater advances in the development of meteorology as a science and a practical contribution to the public good.

F. W. REICHELDERFER, *Chief*
U. S. WEATHER BUREAU

RELEASING A RADIOSONDE

DURING FLIGHT, WHICH USUALLY EXTENDS TO HEIGHTS EXCEEDING TEN MILES, THE RADIOSONDE TRANSMITS BY RADIO SIGNALS A CONTINUOUS RECORD OF THE ATMOSPHERIC PRESSURE, TEMPERATURE AND HUMIDITY OF THE AIR THROUGH WHICH IT ASCENDS.

CHARTER OF SCIENTIFIC FELLOWSHIP

At the conclusion of a meeting of the Division for the Social and International Relations of Science of the British Association for the Advancement of Science on September 27–29, its president, Sir Richard Gregory, announced a "Charter of Scientific Fellowship" which had been drawn up by a Committee of the Division and adopted by the council of the association.

For several years both the British Association and the American Association have been concerned with the interrelations of science and our social order. Every one has been aware of the profound effects of science upon social and political problems, as well as upon our ways of living. Many persons have advocated that scientists should more actively interest themselves in the consequences of their work. For the purpose of putting these ideas into effect, the British organized its new division in 1938, the American Association began to hold programs on Science and Society in 1937, the British and American Associations entered into cooperative arrangements in 1938, and the American Association appointed a special Committee on Science and Society in 1940.

What is a charter of scientific fellowship? Obviously it is a code for relationships among scientists. If science and scientists are as objective and impersonal as they are often said to be, such a code should set a new level for human relationships. It would be free from greed, unworthy ambition, intolerance and malevolence; it would exhibit the qualities of the Sermon on the Mount in the relations among scientific men.

Following a preamble of considerable length, the Charter of Scientific Principles adopted by the Council of the British Association is as follows:

1. Liberty to learn, opportunity to teach and power to understand are necessary for the extension of knowledge, and we, as men of science, maintain that they can not be sacrificed without degradation to human life.
2. Communities depend for their existence, their survival and advancement, on knowledge of themselves and of the properties of things in the world around them.
3. All nations and all classes of society have contributed to the knowledge and utilization of natural resources, and to the understanding of the influence they exercise on human development.
4. The basic principles of science rely on independence combined with cooperation, and are influenced by the progressive needs of humanity.
5. Men of science are among the trustees of each generation's inheritance of natural knowledge. They are bound, therefore, to foster and increase that heritage by faithful guardianship and service to high ideals.
6. All groups of scientific workers are united in the Fellowship of the Commonwealth of Science, which has the world for its province and the discovery of truth as its highest aim.
7. The pursuit of scientific inquiry demands complete intellectual freedom and unrestricted international exchange of knowledge; and it can only flourish through the unfettered development of civilized life.

Six sessions were held at the meeting at which the British Association of Scientific Fellowship was announced. At the second of these sessions Mr. John G. Winant, Ambassador from the United States to Great Britain, served as chairman. The representatives of the American Association at the meeting were Dr. Lewis H. Weed, of Johns Hopkins University, and Dr. Edward Harvey Cushing, of Western Reserve University. The subjects for discussion at the six sessions of the meeting were: Science in Government, Science and Human Needs, Science and World Planning, Science and Technological Advance, Science and Post-War Relief and Science and the World Mind. The participants in the programs included such famous scientists as Professor A. V. Hill, member of Parliament and secretary of the Royal Society; Dr. P. W. Kuo, representative of the Chinese government in the fields of science and

education; Professor J. D. Bernal, Sir John Orr, Professor E. Volterra, Sir John Russell, Dr. Julian S. Huxley, Professor Max Born and Professor L. Hogben.

The degree to which science has increased human relationships was illustrated during the time of the meeting by a two-way radio discussion, arranged by the National Broadcasting Company, between British scientists assembled in London and scientists in America. Not only did the participants on the two sides of the Atlantic confer almost as though they were in the same room, but their words were broadcast throughout England and the United States. The participants in the discussions included Professor A. V. Hill, a Nobel Prize winner in physiology, Dr. Julian S. Huxley, Mme. Eve Curie, Professor Blackett and Mr. Ritchie, in London; and Ambassador Winant, Dr. Harold Urey, Nobel Prize winner in chemistry, Dr. Franz Boas, and Waldemar Kaempffert, in New York.

The spirit of the London meeting and of the transatlantic discussion can not be illustrated better than by the closing words of Ambassador Winant:

> We must recognize already that when we leave the battle fields of this war, we will move into a wounded world of immediate needs and crowded wants in which the healing hands of science and the constructive powers of mechanical arts are an essential part of any brave new world. In our great effort to reestablish political rights which is necessary if we are to have scientific progress and a free mind, we must keep constantly in mind the obligation of science to satisfy the primary needs of man, so that the essentials of life are recognized equally as a part of the rights of man. This is necessary if we are to have security. We must abolish both hunger and the sword as a means of forcing labor. In that way only can we satisfy human needs and give meaning to that equality which proclaimed for all men everywhere the right of life, liberty and the pursuit of happiness.

F. R. M.

AMERICAN PARTICIPANTS IN THE TWO-WAY RADIO DISCUSSION
AT THE TIME OF THE CONFERENCE ON "SCIENCE AND THE NEW WORLD ORDER." *Left:* DR. HAROLD UREY AND WALDEMAR KAEMPFFERT; *right, front:* DR. FRANZ BOAS.

THE PHILADELPHIA BIBLIOGRAPHICAL CENTER AND UNION LIBRARY CATALOGUE

IN January, 1936, in Philadelphia's barn-like Commercial Museum, a force of 125 typists and 35 filers set to work. The typists sat beside microfilm reading machines transcribing on 3 × 5 library cards what they read on the illuminated images before them. The filers, after the cards had been checked for accuracy, arranged them alphabetically in trays.

These workers were men and women on the Philadelphia WPA rolls. Whether justly or not, WPA workers have been charged with raking leaves from one place to another and back again, with leaning on shovels and against themselves. But in this instance the usefulness of the project speaks for itself. After three years' work and the expenditure of nearly a quarter million man-hours and $200,000, a union catalogue of 3,250,000 cards representing 5,000,000 books in nearly 150 libraries in and near Philadelphia had been completed.

Now known as the Philadelphia Bibliographical Center and Union Library Catalogue, it was the largest regional union catalogue in the country and second only in size to the union catalogue in the Library of Congress, which, founded in 1901, has 11,000,000 cards and is, of course, national in scope. This spring, with the addition of the 152d library in the Philadelphia area, the catalogue is now complete save for the addition of some 70,000 cards a year representing new accessions. Exclusive of

PREPARATION OF CARDS FROM MICROFILM READING–MACHINES

IN WHAT SEEMS A MAD-HOUSE, PERHAPS, TYPISTS ARE TRANSCRIBING THE LIBRARY CARDS OF THE PHILADELPHIA BIBLIOGRAPHICAL CENTER AND UNION LIBRARY CATALOGUE FROM MICROFILM READING-MACHINES. THE ACCURACY WAS EVEN HIGHER THAN IN TRANSCRIBING DIRECT FROM THE ORIGINAL CARDS BECAUSE OF THE LARGE SIZE OF THE IMAGE ON THE READING MACHINE.

MR. A. B. BERTHOLD, BIBLIOGRAPHER OF THE UNION LIBRARY CATALOGUE AIDS IN EDITING THE CARDS. IN THE MANY CASES OF DUPLICATION OF THE SAME BOOK IN MORE THAN ONE LIBRARY, ONLY THE TRANSCRIPT OF THE MOST COMPLETE ORIGINAL IS FILED.

$45,000 for equipment and supervision, supplied principally by the Carnegie Corporation, it cost less than five cents to transcribe and file a card, a figure that has interested some librarians. The low cost was made possible by first photographing the original cards on microfilm (16mm), a method originated and first used in the Philadelphia Center.

For research workers in Philadelphia the usefulness of the new Bibliographical Center is obvious. Although interlibrary loans can be obtained from virtually any important library in the United States through the national catalogue in Washington, the mails are slow, and the cost of postage and insurance from perhaps as far away as California mounts up. Why apply to Washington when a phone call to the Fine Arts Building of the University of Pennsylvania, where the center and catalogue are housed, may discover the book right at home and, if the borrower so desires, may even bring it to him by messenger?

But local investigators are not the only ones benefited. Thirty-six per cent. of the items listed are not in the catalogue in Washington. Many of these relate to local history, but obviously, Philadelphia because of its early subscription libraries (such as the Library Company, founded by Franklin), its early prominence in medicine and law and as a center for Quakerism and the immigration of Germans, has rare and frequently unique holdings of Americana and even of English and other literatures and history.

Before the center was established, a prospective borrower might communicate separately with the University of Pennsylvania, which has especially rich collections in Medieval history, Elizabethan literature, the eighteenth century novel, Frankliniana, medicine, law, education, the history of chemistry, to name but a few; with the College of Physicians, said to have one of the finest medical libraries in the world; with the Library Company, which is rich in early American and European imprints; Haverford and Swarthmore Colleges, with their unrivalled collections on Quaker history;

THE FILING CASES OF THE BIBLIOGRAPHIC CENTER
ARE NOT NOTABLE FOR ELEGANCE. FOR ECONOMY THEY WERE CONSTRUCTED STURDILY BUT AS SIMPLY AS POSSIBLE. FOR THE MOST PART BOOKS ARE CATALOGUED BY AUTHOR'S NAME ONLY (WHEN ANONYMOUS BY TITLE). EDITIONS ARE CATALOGUED BY BOTH AUTHOR AND EDITOR.

etc.[1] But now inter-library loans can be made direct. That out-of-town workers are using the catalogue and the bibliographical service its staff supplies is revealed by the fact that they ask for an eighth of the more than 3,000 items now inquired for each month.

The purpose of the center is not primarily to provide a research worker with bibliographies, but rather to locate a book once the worker knows the name of its author. It does, however, direct him to collections of bibliographical apparatus, as, for example, the unusually complete collection of the catalogues of English and other European libraries found in the Library of the University of Pennsylvania. It also provides a means of integrating and making more intelligent the current acquisitions of member libraries. Its fundamental purpose is to make the exceptional holdings of Philadelphia libraries better known by serving as a clearing-house on resources and services. It directs inquirers to the agencies from which they can get authoritative information. Librarians nowadays do not wish to keep their treasures from the eyes and hands of qualified users, and that to a large extent explains the generous cooperation given by member libraries.

CORNELL M. DOWLIN

[1] A full account of Philadelphia library resources is in "Philadelphia Libraries and Their Holdings," published this spring by the University of Pennsylvania Press (fifty cents). Perhaps for readers of THE SCIENTIFIC MONTHLY, special mention should be made of the libraries of the Academy of Natural Sciences and the Franklin Institute, which are superb in natural history and engineering respectively. The films used in making the union catalogue are available for inter-library loans. They provide a means of determining very rapidly the holdings of a particular library.